Model 98RK-1 & Model 9816
Rackmount Intelligent Pressure Scanner
User's Manual

August 2012

NetScanner™ System

www.meas-spec.com

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The **Model 98RK-1 Scanner Interface Rack** is the latest generation chassis for the rackmounted version of Measurement Specialties' proven **NetScanner™ System.** The primary feature of the 98RK-1 rack is the incorporation of an auto-negotiating gigabit switch to increase data integrity and transmission speed while reducing potential network collisions to the host computer.

Measurement Specialties offers an upgrade kit for customers who have an existing 98RK Scanner Interface Rack and for users who want to take advantage of the additional features offered by the **98RK-1**. The upgrade kit includes a pull-out tray with all new electronics, a new front panel for the rack, and new rear panel connections.

For additional information, please contact the **Sales Department** at Measurement Specialties, Inc., at (757) 766-1500, or toll free 1-800-678-SCAN (7226).

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Our Company

Measurement Specialties Incorporated, (MEAS) develops, manufactures, and services level and pressure measuring instruments where the highest level of traceable accuracy is required for aerospace, industrial, municipal, and environmental applications. Our products have become the world standard for electronic level and pressure measurement and scanning. We are committed to the highest quality design, manufacture, and support of level and pressure instrumentation that is in the best interest of our customers. MEAS is an ISO-9001:2000 certified company.

Our Warranty

Measurement Specialties, Inc., warrants all **NetScanner™ System** products to be free of defects in material and workmanship under normal use and service for one (1) year.

Technical Support

Monday through Friday, during normal working hours, (7:30 am through 5:30 pm, Eastern time) knowledgeable personnel are available for assistance and troubleshooting. Contact the **Applications Support Group** or the **Customer Services Department** at Measurement Specialties (**757-766-1500** or toll free **1-800-678-SCAN)** if your instrumentation is not operating properly or if you have questions concerning any of our products. E-mail assistance is available by contacting Applications@meas-spec.com.

Website and E-Mail

Visit our website at www.meas-spec.com to look at our new product releases, application notes, product certifications, and specifications. E-mail your questions and comments to us: Sales@meas-spec.com.

Our Firmware

This manual was prepared for various versions of module firmware as were released at the time of this manual publication. Addenda will be distributed as deemed necessary by MEAS. Any questions regarding firmware upgrades may be addressed to the **Applications Support Group**. Firmware revisions, manual addenda, and utility software may also be obtained from the MEAS website at www.meas-spec.com.

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Chapter 1

General Information

1.1 Introduction

This User's Manual will:

- Explain the electrical and pneumatic pressure connections for the **Model 98RK-1 Scanner Interface Rack** and **Model 9816 Rackmount Intelligent Pressure Scanners**.
- Provide computer set-up instructions to make a proper Ethernet connection on most Windows® -based personal computers.
- Instruct you on using the start-up software to manipulate and acquire data from each Model 9816 scanner in the rack.
- Instruct you on how to program each module with computer software.

Figure 1.1
Model 98RK-1 Scanner Interface Rack with
Model 9816 Rackmount Intelligent Pressure Scanners

The **NetScanner™ System** is a comprehensive, distributed data acquisition system centered around our proven Intelligent Pressure Scanner technology. The rackmount configuration of this system is comprised of **Model 98RK-1 Scanner Interface Racks**, each housing up to eight (8) **Model 9816 Rackmount Intelligent Pressure Scanners** networked via the Ethernet interface. The 98RK-1 chassis provides communication, power supply and pneumatic connections to the 9816 scanners. The 98RK-1 utilizes an integral gigabit switch to connect all scanners to a host computer. Each 98RK-1 can also provide power and communication to as many as three (3) remotely connected NetScanner modules such as the **Model 9116 Pneumatic Intelligent Pressure Scanners**, **Model 9022 All-Media Intelligent Pressure Scanners**, **Model 9046 Intelligent Temperature Scanners**, and **Model 903x Pressure Controllers**. Refer to their respective datasheets for more information on these NetScanner System components. A typical system configuration is shown in Figure 1.2.

Each Model 9816 Rackmount Intelligent Pressure Scanner module integrates sixteen (16) silicon piezoresistive pressure sensors and a unique patented calibration manifold with an onboard 32-bit microprocessor. This provides compensated engineering unit (EU) data output via the Ethernet interface. Each pressure sensor is packaged with an integral EEPROM for storage of calibration data unique to the sensor. Integrating the EEPROM within the sensor enables simple 'plug and play' field replacement of transducers with automatic uploading of sensor data during system power-up.

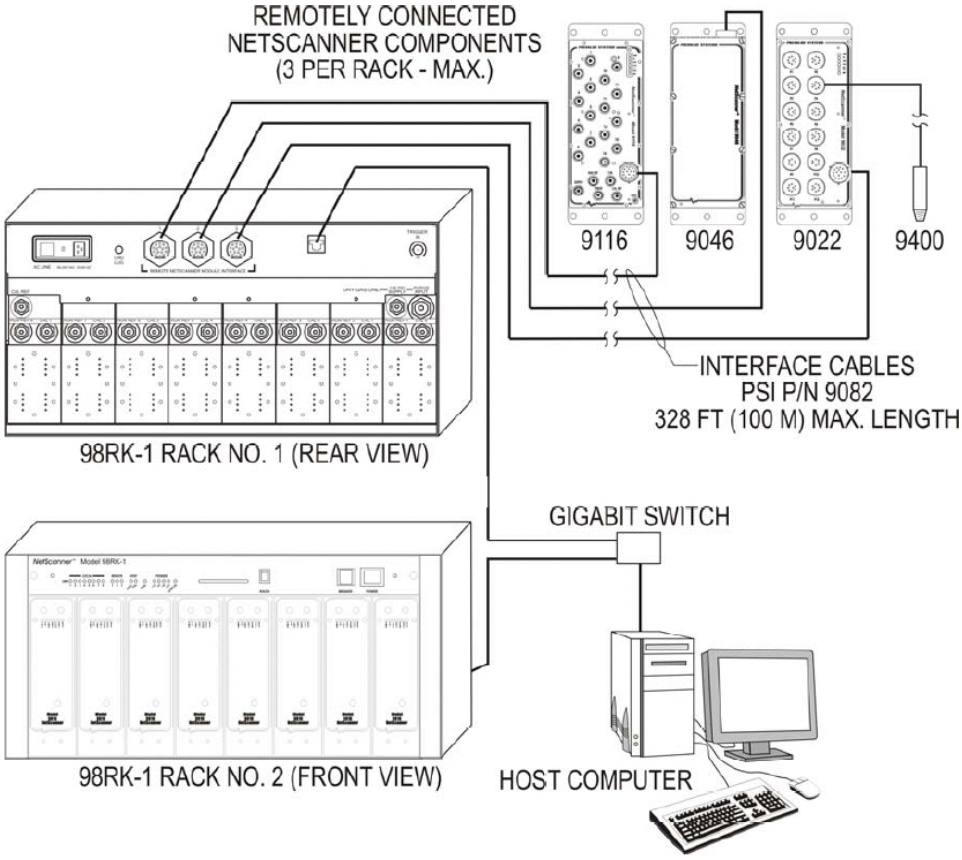


Figure 1.2
Typical NetScanner System Configuration

Data uploaded from the EEPROMs is used by the microprocessor to correct zero, span, linearity, and thermal errors. Digital temperature compensation of the piezoresistive sensors reduces thermal errors by a factor of ten or more over conventional sensor compensation. The microprocessor also controls the execution of on-line zero or span calibrations upon request. On-line re-zero virtually eliminates sensor zero drift error and provides guaranteed system accuracy of up to ±0.05% FS (Full Scale) after re-zero.

Firmware within each **9816 scanner** provides the capability to sample using up to three (3) scan lists concurrently at rates up to 100 measurements per channel per second. The **NetScanner™ System** is supplied with software for PC compatible computers.

1.2 Description of the Instruments

Model 9816 Intelligent Pressure Scanners are available with 16 (sixteen) measurement channels, each with individual pneumatic transducers per channel. The most distinctive features are highlighted below:

- Pre-calibrated Transducer - a memory chip containing full thermal calibration data is embedded within each internal transducer.
- Individual transducer per measurement input channel.
- Mixed transducer ranges may be installed in a single module.
- Low cost per point - per-channel cost is less than a typical industrial pressure transducer/transmitter.
- High accuracy - **Model 9816** pressure scanners are capable of accuracies up to ±0.05%. Accuracy is maintained through use of built-in re-zero and span calibration capabilities. Accuracy is maintained for six (6) months after calibration.
- Low thermal errors - each transducer of a pressure scanner module contains an individual temperature sensor and thermal calibration data for internal use by software correction algorithms. Thermal errors are reduced to ±0.001%FS/ºC over the calibrated temperature span.
- Re-zero upon demand - an integrated calibration valve allows for automatic re-zero adjustment calibration of dry gas transducers to null offset drift errors.
- Ease of transducer replacement - factory calibrated transducer assemblies may be stocked and rapidly replaced in the field. Storage of thermal coefficients within the transducer allows for '**plug and play**' transducer replacement.
- Ease of calibration - **98RK-1 Scanner Interface Rack** features pneumatic hook-ups on the back-panel and front-panel (if ordered) to ease scanner calibration. Each 9816 Intelligent Pressure Scanner module contains a pneumatic calibration manifold and software commands to automatically perform re-zero and span adjustment calibrations. New offset and gain coefficients that result from the most recent calibration may be stored in non-volatile transducer memory.

- The **98RK-1 Scanner Interface Rack** features a gigabit switch that significantly increases processing capabilities and speed.
- System calibration consists of zero and span calibration only at any given temperature. Full thermal re-calibration is never necessary.
- Ease of use - modules have simple command sets and provide engineering units (EU) output. They may interface directly to a desktop or laptop computer or they may be interconnected into a large network controlled by many types of host computers.
- Connectivity - use of industry-standard TCP/UDP/IP communications network protocols to control and read data from **NetScanner™ System** modules ensures compatibility with third party hardware and software.

1.3 Options

1.3.1 Pressure Ranges

Model 9816 Intelligent Pressure Scanners contain sixteen (16) DH200 transducers. These DH200 transducers are available with full scale pressure ranges from 10" H_2O (inches of water column) to 850 psid (2.5 kPa to 5860 kPa). Transducers with different pressure ranges may be combined in a single module.

Please consult the Sales Department at Measurement Specialties at 1-800-678-SCAN (7226) for availability of other pressure ranges as well as other modules which may be attached to the **98RK-1 Scanner Interface Rack**.

1.3.2 Manifolds and Pressure Connections

The **Model 9816** sixteen-channel Intelligent Pressure Scanner is available with either a true differential (reference per port) or common differential (single reference port) pneumatic manifold, and are both equipped with a purge and leak-check manifold. The standard front-mount input and the optional rear-mount input for the 9816 scanner both include a rectangular quick disconnect (QDC) plate with 0.063" (0.040" optional) bulge tubes.

Compression fittings (1/8", 1/16", or ¼" tube outside diameter (O.D.)) are available only for common reference, front-mount scanners. True differential scanners are only available with bulged tubulation front-mount QDCs. Consult the Sales Department at Measurement Specialties for availability of other input fittings.

1.3.3 Communication Interfaces

All Intelligent Pressure Scanners provide digitally temperature compensated and linearized pressure data in engineering units through an Ethernet communications interface to a host computer.

Model 9816 Intelligent Pressure Scanners have a 10Base-T Ethernet host communications interface using industry standard TCP/UDP/IP protocols. This interface provides high data transfer rates (10MBit/sec.) and system connectivity.

The **98RK-1** incorporates a gigabit switch which auto negotiates the highest speed connection supported by the connected equipment. The **98RK-1** incorporates a universal input AC-DC power supply accepting input voltages from 90-250 VAC at 50 or 60 Hz and is capable of supporting a full complement of NetScanner products.

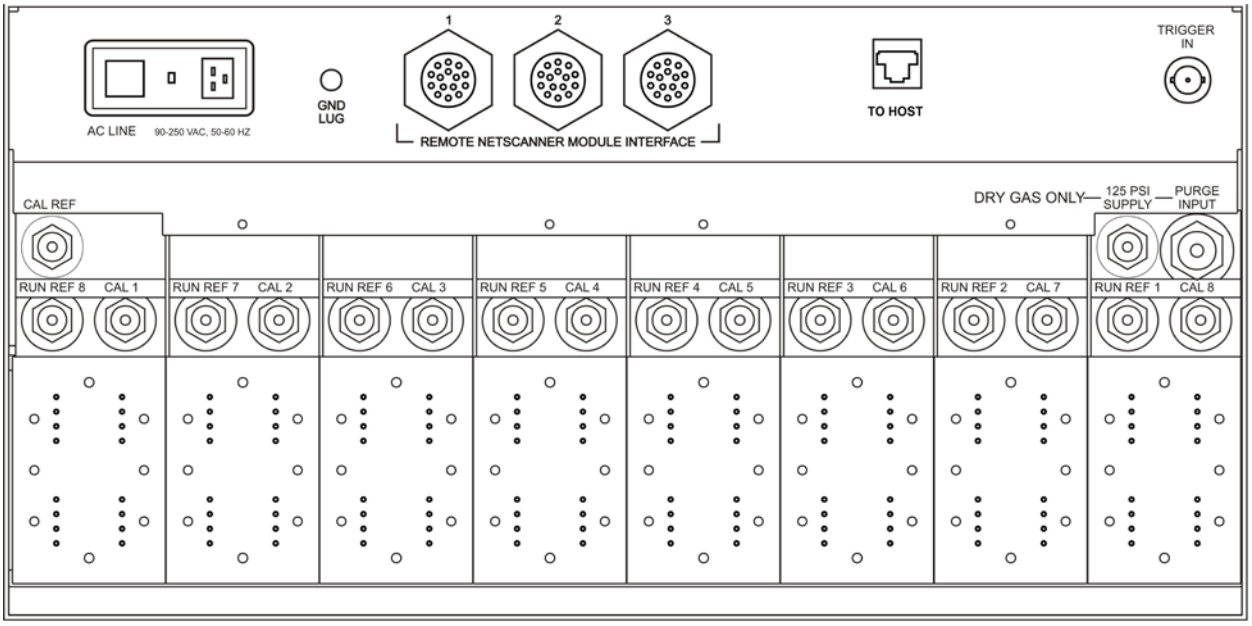


Figure 1.3
98RK-1 Rear Panel

Chapter 2

Installation and Set Up

2.1 Unpacking and Inspection

Before assembling the system, use the shipping bill as a reference to ensure that all parts have arrived. Measurement Specialties takes no responsibility for equipment that is damaged during shipment. If containers are broken, ripped, or damaged, contact the transportation carrier. If the equipment itself appears to be damaged, contact the Repair Department at MEAS at 1-800-678-SCAN (7226).

Each **s**hipment will contain one or more of the following components:

- **98RK-1 Scanner Interface Rack** chassis
- 9816 Intelligent Pressure Scanner modules (installed in the **98RK-1**, if ordered)
- Start-up software (**NUSS**) on CD-ROM
- 9882 Pneumatic Blanking Unit (if purchased)
- **98RK-1 Scanner Interface Rack** User's Manual on CD-ROM.

2.2 Safety Considerations

It is always a good idea to wear safety glasses when operating this equipment or when working with pressurized lines. Always ensure that high pressure lines are properly secured and that all pneumatic lines are rated for the proper pressure and temperature environments.

Ensure that the rack **Power Switch** is turned **OFF** before plugging the Scanner Interface Rack into a power receptacle. Always check line voltages and ensure the correct voltage for your Scanner Interface Rack prior to plugging into the receptacle.

2.3 Connections and Setup

2.3.1 98RK-1 Chassis Connections with 9816 Scanners

STEP 1	Ensure correct line voltage and that the Power Switch for the **98RK-1** is in the **OFF** position. Connect the **98RK-1** chassis to an adequate power receptacle and connect an Ethernet cable from the **98RK-1's** host port (TO HOST) to an optional 10/100/1000Base-T hub, switch, or directly to your computer's Ethernet card.

Figure 2.1 (on the next page) depicts a typical **NetScanner™ System** array. Although this figure depicts the front and back of two **98RK-1 Scanner Interface Racks**, multiple **98RK-1 Racks**, with up to eight (8) scanners per rack, may be networked together. Each chassis provides scanner power supplies and pneumatic connections as well as switch circuitry for up to eleven (11) 10/100Base-T connections, and a 10/100/1000Base-T (gigabit) host link. This enables each chassis to connect with the host computer as well as with up to three (3) additional scanners (and/or standard/ calibration units) which may be externally attached to each rack.

2.3.2 Connections for External Modules

STEP 2	If you are connecting a Model 9016/9116, or 9021/9022 Intelligent Pressure Scanner, a Model 903x Intelligent Pressure Calibrator or Standard, or a 9046 Intelligent Temperature Scanner to the rear of your **98RK-1**, connect the ruggedized circular connector of the 9082 cable to your scanner's connector port. Connect the other end of the same cable to one of the ports on the rear of the **98RK-1** chassis labeled "Remote NetScanner Module Interface." (See **Figure 2.1**)

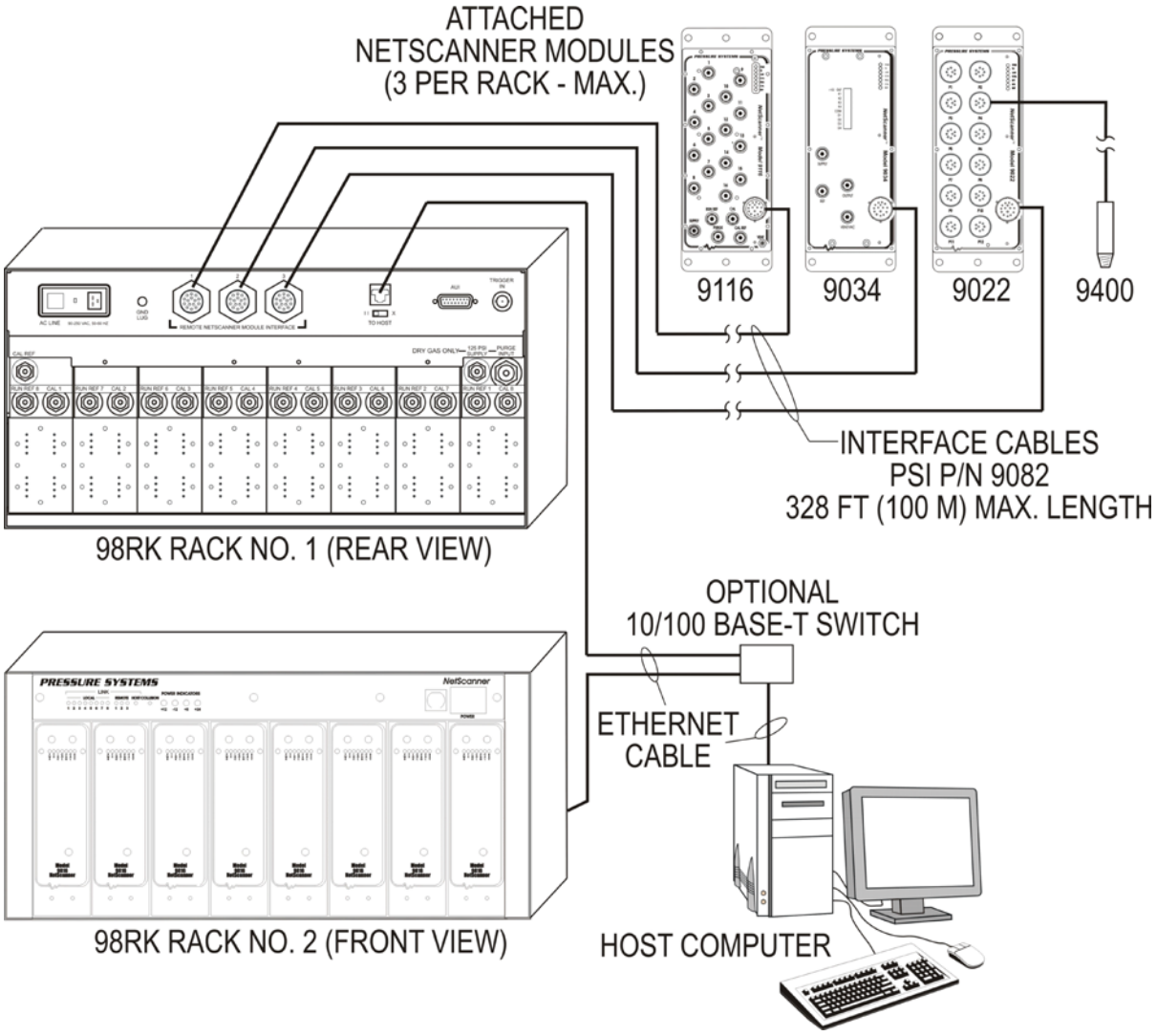


Figure 2.1
Typical Hook-up Arrangement
Using the 98RK-1 Scanner Interface Rack

2.3.3 Network Communications Hookup

The **98RK-1 Scanner Interface Rack** chassis has an Ethernet connector port on the rear of the unit through which all scanners in the rack may be connected to the network or the Ethernet card in your PC or work station. This port is labeled **" TO HOST"** (using an RJ-45 connector). Similarly, every Model 9016, 9116, 9021, or 9022, 903x and 9046, has an Ethernet connecting port using TCP/IP transmission protocol through their single circular connector.

STEP 3	If required, install an Ethernet card in your computer.

STEP 4	Set up or confirm the TCP/IP protocol and address of the host computer as shown in the following steps.

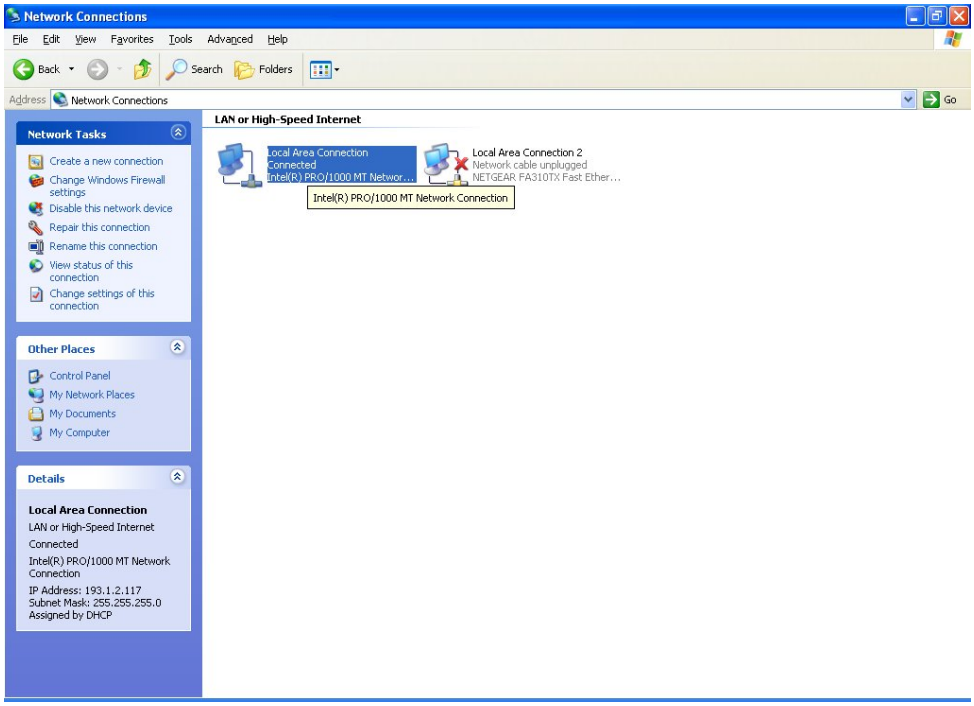
Communications via Ethernet using TCP/IP protocol uses module address designations and requires the host computer to have a compatible address.

STEP 5	Find the "Network Connections" icon on "Control Panel." Double-click the icon to arrive at the "LAN or High Speed Internet" screen. Find the "Local Area Connection" icon and select it (Left click). Select "Properties" from the "Local Area Connection" by right clicking the icon. A screen example is shown on the next page.

Note

All of the screen examples in this User's Manual are from Windows® XP operating system. If you are using a different operating system and need assistance in setting up your network, contact the Applications Support Group at Measurement Specialties.

STEP 6	Scroll down the "Local Area Connection" tab to ensure that "Internet Protocol TCP/IP" is available. NOTE: a dial-up adapter may also exist for internet access. This is **NOT** the protocol that is being verified.

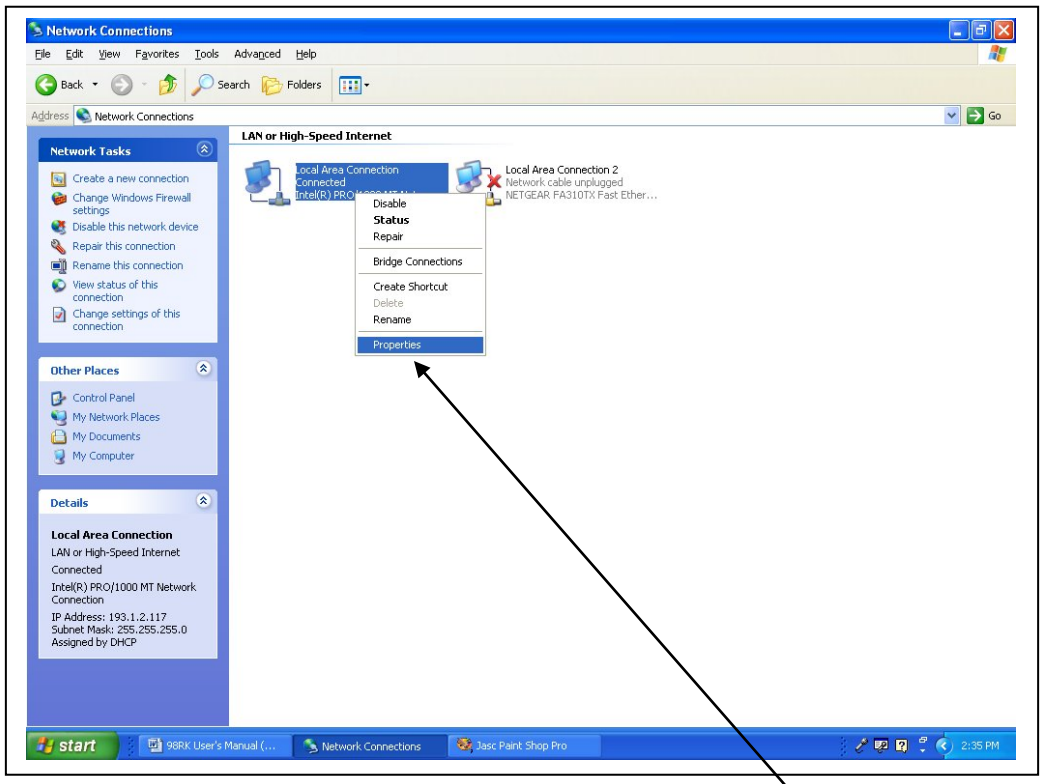


Initial Network Screen for Windows® XP

STEP 7	With your mouse, right-click on the "Local Area Connection" icon. A drop-down menu will appear. Scroll down the menu and select (left-click) the "Properties" line.

STEP 8	Scroll down the "Local Area Connection" tab to ensure that "Internet Protocol TCP/IP" is available. NOTE: a dial-up adapter may also exist for internet access. This is **NOT** the protocol that is being verified.

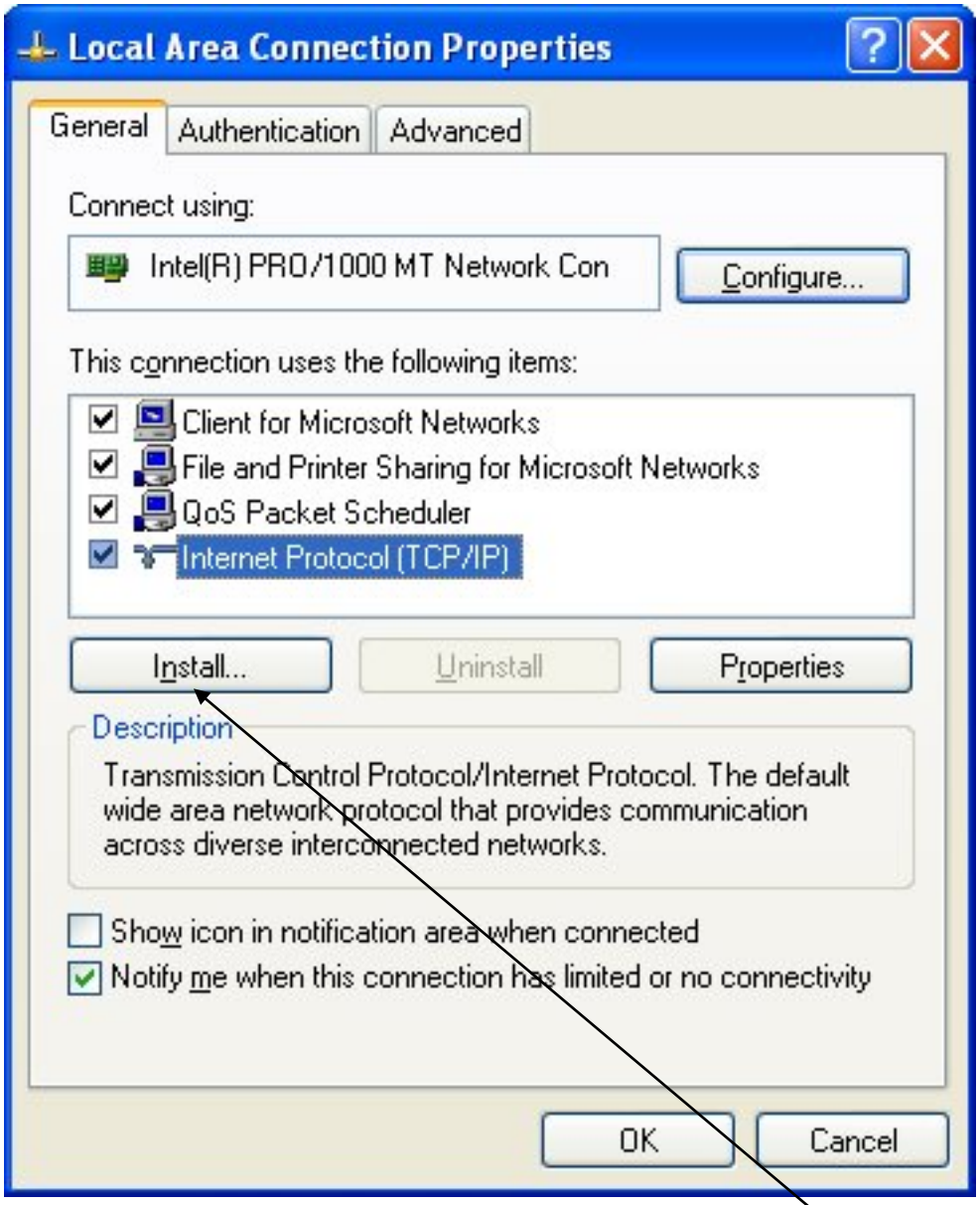
A screen example is shown here.



STEP 9 With your mouse, right-click on the "Local Area Connection" icon. A drop-down menu will appear. Scroll down the menu and select (left-click) the "Properties" line.

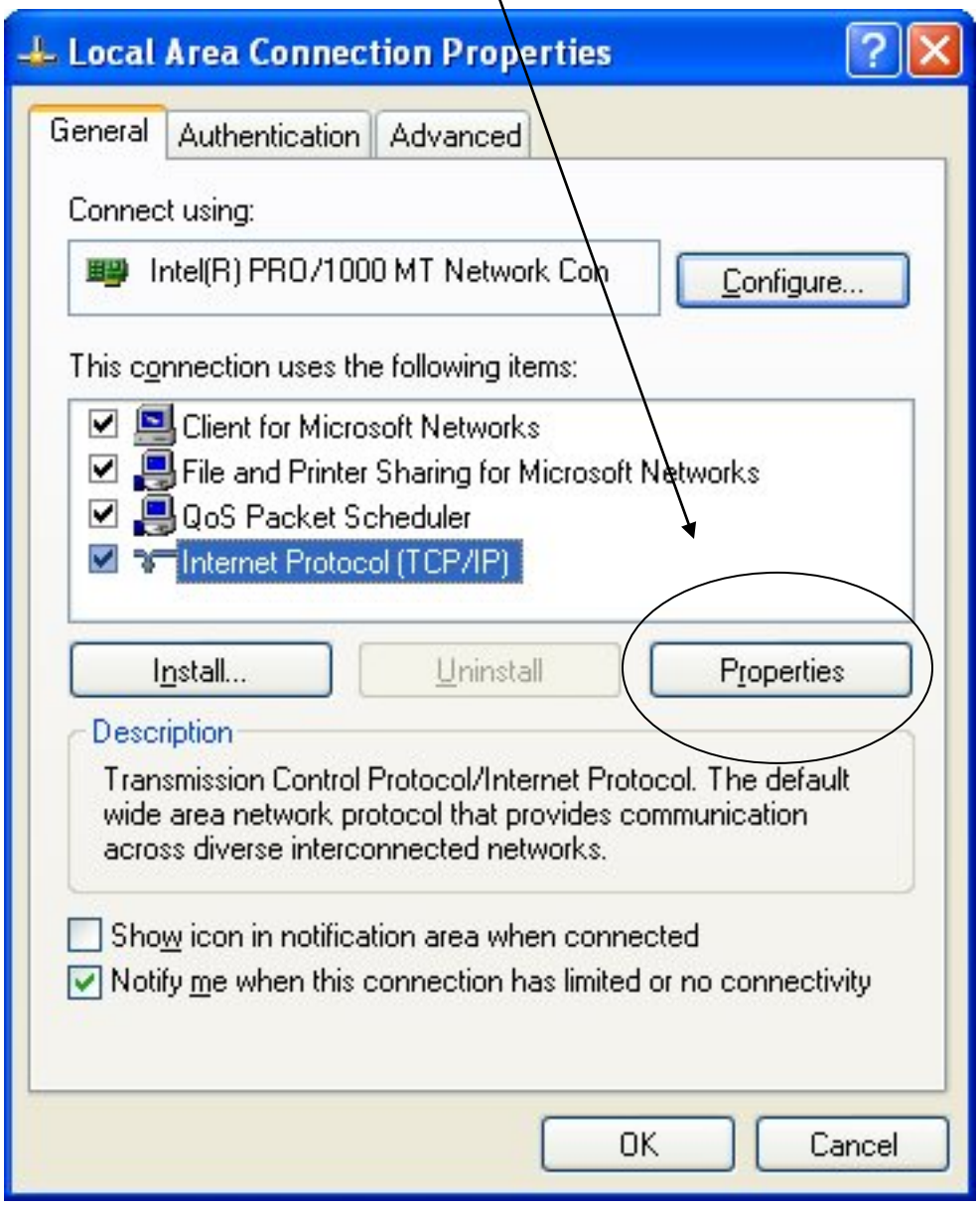
A screen example is shown on the next page.

STEP 10 Scroll down the "Local Area Connection Properties" tab to ensure that "Internet Protocol TCP/IP" is available. NOTE: a dial-up adapter may also exist for internet access. This is **NOT** the protocol that is being verified.

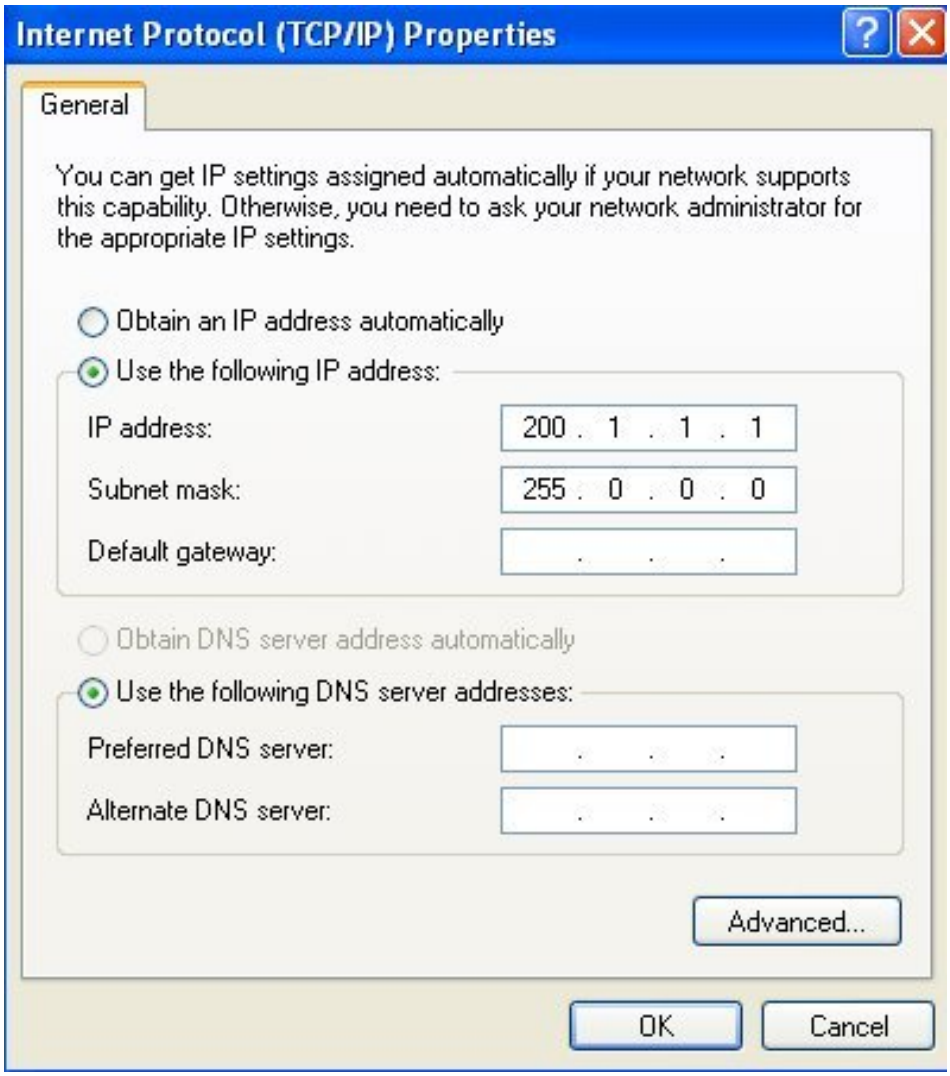


STEP 11 If the TCP/IP protocol is not found, it must be installed. To install, select "Install" as shown on the "General" tab on the "Local Area Connection Properties" screen.

STEP 12	Once the correct TCP/IP protocol is installed and verified for the proper Ethernet card, the IP address (under TCP/IP Properties), that is compatible with the pressure scanner(s), must be set.



A typical screen example with IP and Subnet Mask addresses for a 9816 scanner is shown on the next page.


Internet Protocol (TCP/IP) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address:
200 . 1 . 1 . 1
Subnet mask:
255 . 0 . 0 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Advanced...
OK
Cancel

STEP 13

To set the PC address: Select "Use the following TCP/IP address." It is suggested that the IP Address read 200.xxx.yyy.zzz where xxx, yyy, and zzz are unique locations that do not match any other address on the network. (Check with your network administrator to see that the numbers chosen do not conflict with any other addresses on the network.) It is suggested that the IP address should, as a default, read 200.1.1.1. This should allow you to talk with any other modules on the network. The Subnet mask *should* read 255.0.0.0. Select OK. The host computer is now set to communicate via the Ethernet card to the 9816 module.

STEP 14	Connect the Ethernet cable between the **98RK-1** "TO HOST" RJ-45 connector and the Ethernet card of your host computer.

After you set the IP address and the subnet mask, click "OK". You may then be prompted to re-start your computer so that the inputs will be recognized.

The host computer and each module must have a unique *Ethernet Hardware Address* and a unique *IP* Address. The Ethernet Hardware address is generally fixed (at manufacturing time of the Ethernet microprocessor board inside the module). The Ethernet Hardware address is shown on each **NetScanner™ System** module's label. The Ethernet Intelligent Pressure Scanners are capable of supporting various methods for IP *address assignment*, using either the factory default or user-configured Static IP addressing or Dynamic IP address assignment. Dynamic IP address assignment is through the use of RARP or BOOTP protocols. Unless your application requires the use of Dynamic IP address assignments, it is strongly suggested that the module be left configured to use the Static IP address. ***The default method is typically the simplest method for using the Intelligent Pressure Scanner*.**

Note **After closing the TCP/IP connection to a module, the host must wait 10 seconds before reconnecting.**

The software (shipped with your module(s)) is called **NetScanner Unified Startup Software (NUSS)** and is designed to be compatible and operate with most Windows®-based operating systems.

STEP 15	Insert the CD-ROM containing the software shipped with your NetScanner™ System (**NUSS**) into the appropriate drive of your computer. Using your Windows® "Start/Run" button, type D:\SETUP (or use appropriate drive designation), and follow any on-screen instructions. This will load the **NUSS** software onto your hard drive**. NUSS** is self-installing from your CD-ROM, or may be downloaded from our website (www.meas-spec.com). It may be installed multiple times and on as many computers as desired.

The executable file will automatically be installed as (typically):

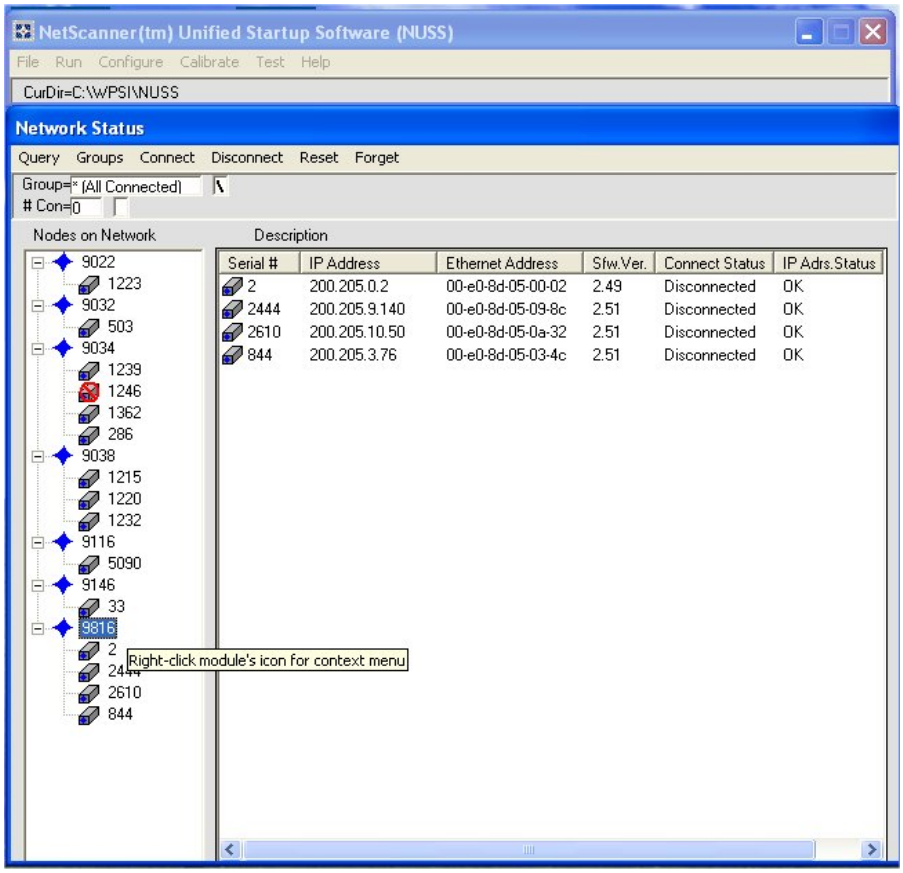
C:\ NUSS\NUSS.EXE

STEP 16	Turn the **98RK-1** power switch **ON** and wait approximately thirty (30) seconds for the scanners to perform self-diagnostics. The scanners automatically upload the calibration data stored within each transducer at start-up. Newly installed transducers are automatically ready to be used without further calibration.

STEP 17	Select (double click) the executable file (**NUSS.EXE**) using "Windows Explorer" or "My Computer" or select (double click) your desktop shortcut icon. (See Appendix C for instructions on how to create a shortcut icon.)

The initial screen of the **NetScanner™ System** software (**NUSS**) is shown on the next page.

At this point, the best way to see if you have correctly connected your **NetScanner™ System** with the **98RK-1 Scanner Interface Rack** is to observe the Host Link (LNK) light, located on the front panel of the **98RK-1**. The **98RK-1** will auto-negotiate for maximum speed connections (up to 1 gigabit/sec) and will automatically correct for swapped signal pairs. With the LNK light **ON**, the system is correctly connected to your Ethernet network or host computer. The 98RK-1 will display a yellow LNK light when it has negotiated a 10T Ethernet connection, green for 100T or blue for a gigabit connection. The LNK light will blink during communications activities. If the LNK light is **not ON**, re-trace your steps to find the connection error. You may use the " **ping"** utility as described in the **Chapter 6**, **Troubleshooting**, in this manual to check proper electrical connection and TCP/IP configuration.

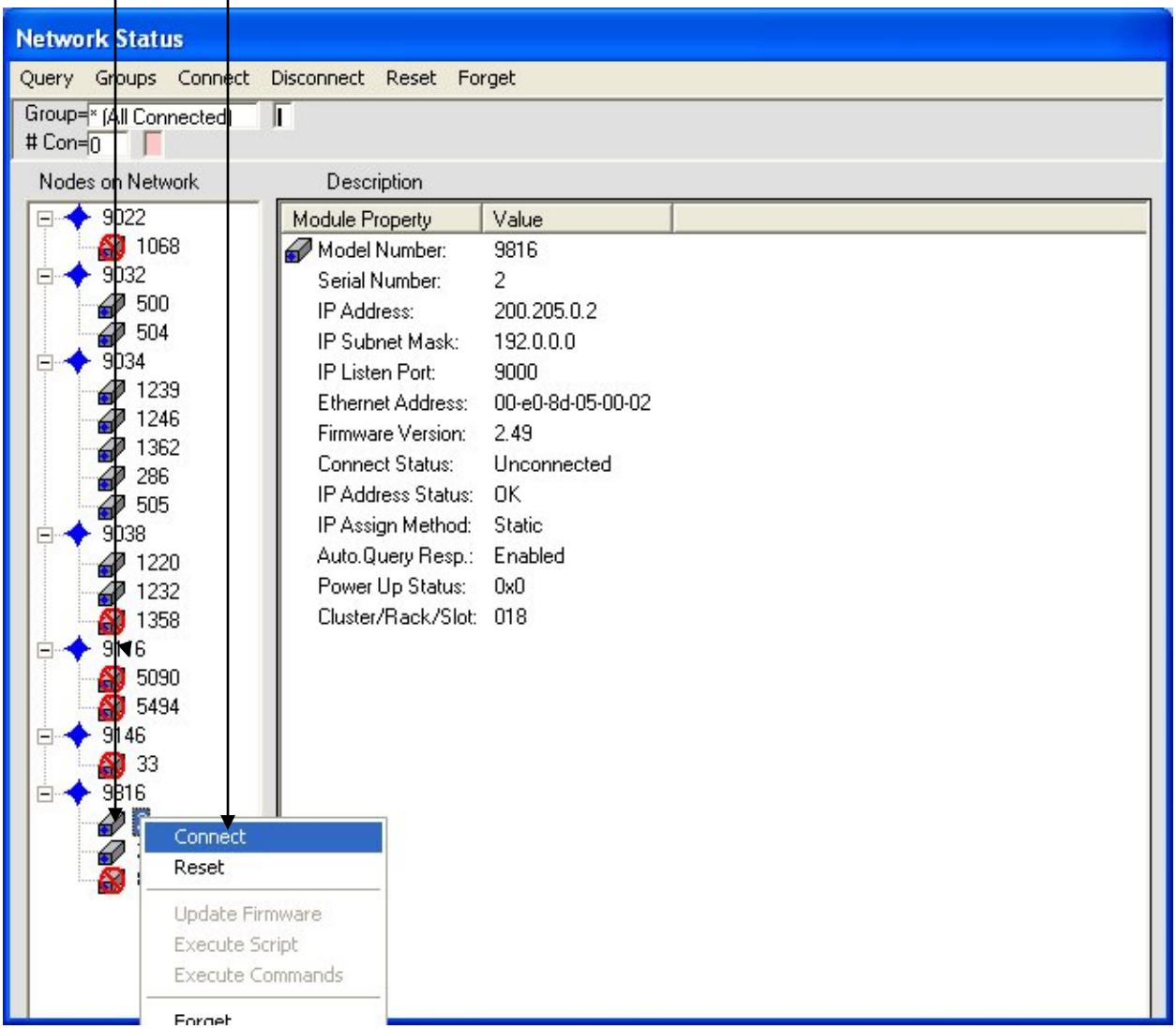


NUSS Initial Screen

Once NUSS is selected, the Network Status Screen (shown above) appears. Note that a "Querying Network" message briefly appears, and then the Nodes on Network box will automatically display the each **NetScanner** module hooked into the network. It also shows their serial number, IP address, and whether or not they are active (connected or disconnected).

Connect to any module. (When a connection has been established, the top of the module icon will turn yellow.)

STEP 18 Select (left click) the module's icon in the Node map. Right-click on the module's icon (in either the Node Map or the description box), and select (left click) on "Connect" in the pull-down menu that appears. (See screen depiction below.)



As stated above, if the module's icon does not turn yellow when selected, the module did not connect. Some possible causes for a failure to connect are:

- There is an IP address incompatibility between the host computer and the module.
- There are two modules with the same IP address.

For complete instructions on using **NUSS** for operating your modules, please refer to the **NUSS** User's Manual, available from Measurement Specialties.

2.3.4 Pressure Connections

Pneumatic connections for the sixteen (16) measurement inputs of the Model 9816 Intelligent Pressure Scanners installed in the **98RK-1 Scanner Interface Rack** may be found either on the backplane of the **98RK-1** chassis or on the 9816 front plate, depending on the particular configuration you ordered. Additional control, purge, and calibration inputs are found on the rear of the **98RK-1**. The function of each input port is clearly engraved or printed next to each input (see **Figures 2.2, 2.3** and **2.3a**, next page). Connections are through bulge tubing, compression fittings, or special user-supplied fittings on the tubing plate. All pneumatic inputs to these modules should contain dry, non-corrosive gas only.

As a standard, all **Model 9816** Intelligent Pressure Scanners are supplied with the purge/leak check calibration manifold. Through software commands to each 9816, this valve may be placed in one of four positions; **RUN**, **CAL**, **PURGE**, or **LEAK-CHARGE**. See functions 0C and 12 of the ***Set/Do Operating Options/Functions*** **('w')** command in **Chapter 3** for more information. Pneumatic input requirements for these four operating positions are described in following sections.

Here are some guidelines which should be followed when installing pressure connections to all **NetScanner™ System** Intelligent Pressure Scanner modules.

- It is always a good idea to wear certified safety glasses when working with pressurized lines.
- Ensure that your input pressure will not exceed the proof pressure ratings of the corresponding instrument transducer. Applying excessive pressure to measurement inputs can permanently damage the pressure transducers.
- Ensure that all tubing material is rated for the expected pressure and environmental conditions. Failure to use the proper tubing material may result in ruptured lines and possible personal injury.
- Ensure all high pressure lines are properly secured.
- Place retaining springs over all bulge tube fittings to ensure pneumatic lines remain attached and leak free. Springs should be pushed down on connections so that half of the spring length extends past the tube bulge.

WARNING: Introduction of contaminants to the module pneumatic inputs may damage transducers, manifolds, and O-ring seals.

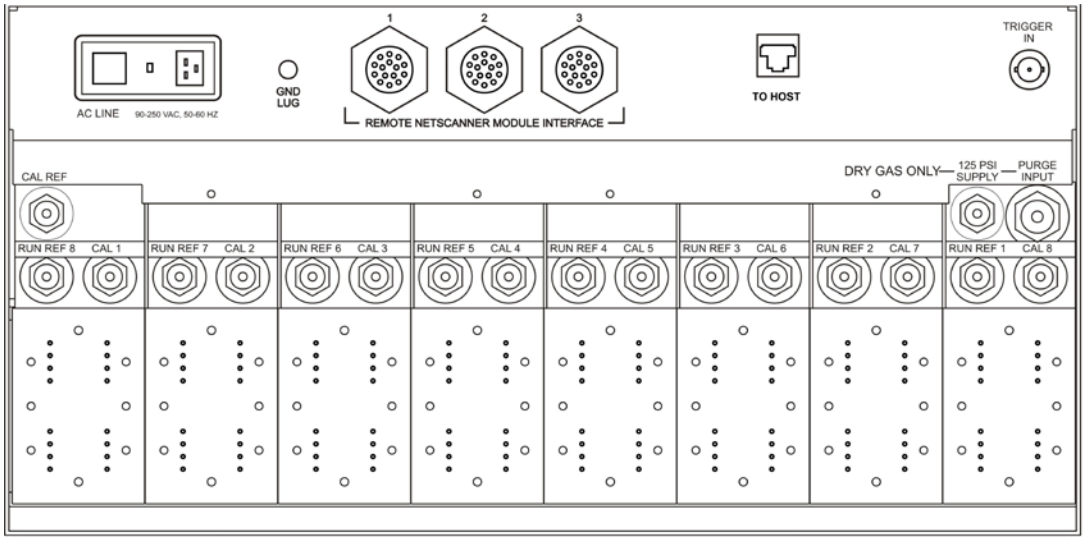


Figure 2.2
98RK-1 Rear View

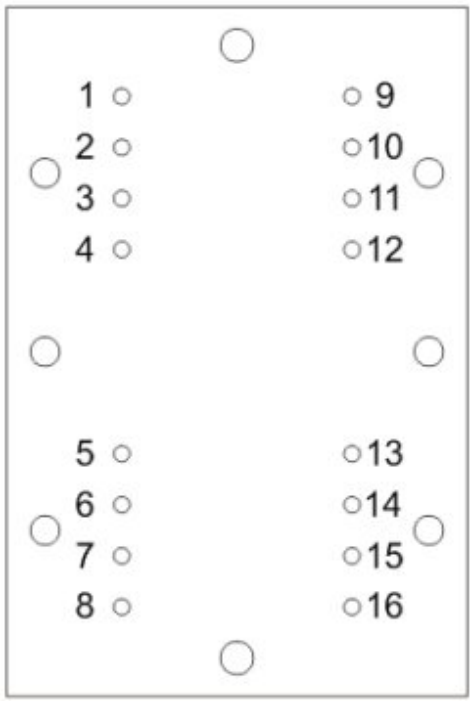


Figure 2.3
Expanded View of 98RK-1 Scanner Interface Rack Rear Manifold

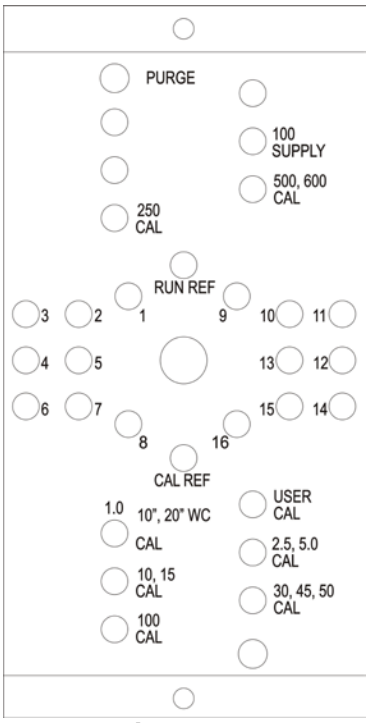


Figure 2.3a
Expanded View of Model 9816 Intelligent Pressure Scanner Rear Manifold

2.3.4.1 Supply Air

The 98RK-1 chassis requires an 80 psig minimum (125 psig maximum) dry **air** (or inert gas) supply which is used to shift the 9816 internal calibration valve (in each scanner) between its different positions. Each 98RK-1 contains a fitting marked "**SUPPLY**" for this input (see **Figure 2.2**, previous page). Internal solenoid valves in each 9816 scanner direct this supply pressure to the proper control port on the calibration valve as required by instrument commands. The absence of sufficient supply air to the module will prevent the calibration valve from shifting into requested positions (i.e., **RUN**, **CAL**, **PURGE**, or **LEAK-CHARGE**). The pneumatic input manifold (on the rear of the chassis) contains an additional two transducers to read the supply and purge air pressures.

STEP 19	Connect 80-125 psig dry air to the chassis SUPPLY port. This is the power used to move the internal calibration valve between the four locations; RUN, CAL, PURGE, and LEAK-CHARGE.

WARNING: Supply air should not exceed 125 psi (875 kPa). Excessive pressure may damage the internal solenoids.

2.3.4.2 RUN Mode Inputs

The standard pneumatic quick disconnect (QDC) tubing plates contain sixteen (16) numbered pneumatic input channels. These numbered inputs are attached to corresponding pressure transducers inside the instrument and should be pneumatically attached to the pressure measurement points under test.

The 98RK-1 pneumatic backplane also contains inputs labeled **RUN REF** (**RUN REF 1 through RUN REF 8**). With the common reference manifold, **RUN REF 1** is the reference port for any 9816 scanner installed in 98RK-1 slot #1 (leftmost position when viewing from the front of the 98RK-1). **RUN REF 8** is the corresponding reference for any 9816 scanner installed in 98RK-1 slot #8. The **RUN REF** inputs are pneumatically connected to the reference side of all internal DH200 pressure transducers, as shown in **Figure 2.4** (next page).

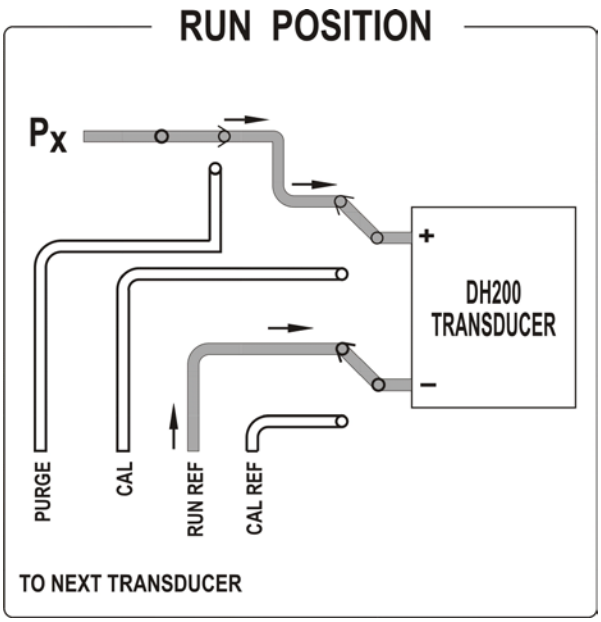


Figure 2.4

Optionally, the unit may be ordered with a true differential (reference per channel) manifold. The **RUN REF** connection is used for situations where all channels have one reference pressure. This input may also be left unattached to provide atmospheric reference pressure.

When using instruments with the reference per channel option (true differential), two (2) pneumatic inputs will be provided for every numbered channel. These inputs are labeled "**P**" and "**R**". The "**P**" connection is the test pressure input. The "**R**" connection is the transducer reference input pressure. Since each channel has its own reference pressure input, the **RUN REF** input is not provided on the true differential tubing plate.

2.3.4.3 CAL Mode Inputs

The 9816 model (in the 98RK-1) contains pneumatic backplane inputs for **CAL**(**CAL 1-8**) and **CAL REF**. When the module's internal calibration valve is placed in the **CAL/RE-ZERO** position, all DH200 transducer *pressure* inputs are pneumatically connected to the **CAL** input ports. All DH200 *reference* inputs are pneumatically connected to the **CAL REF** input port. The **CAL** input may be used to perform on-line zero adjustment of the transducers. The **CAL** input may also be used for DH200 span adjustment calibrations and accuracy tests if appropriate pressure calibrators (such as the 903x series) are available. Span calibration of multi-range scanners may also utilize the **CAL 1-8** ports if the highest applied pressure does not exceed the proof pressure rating of any other installed transducer, otherwise the individual transducers must be calibrated with the valve in the **RUN** position.

When the internal calibration valve is in the **CAL/RE-ZERO** position, the **RUN** inputs (**RUN REF** and numbered input ports) are pneumatically dead-ended to prevent migration of contaminants into the instrument.

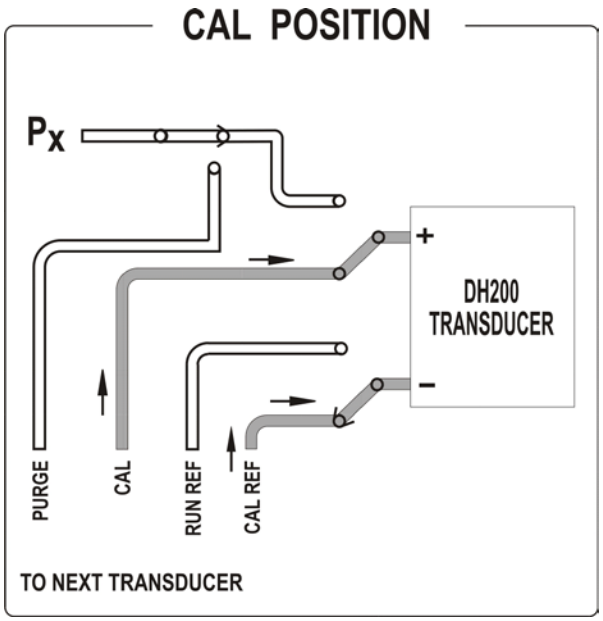


Figure 2.5

Each 9816 is manufactured with a connection to one of the eight (8) **CAL** port ranges, based on the unit's full scale pressure range. Assignment of 9816's **CAL** range is show in **Table 2.1** (next page). In the case of a 9816 with multiple pressure ranges installed, the unit will use the **CAL** range of the lowest installed full scale pressure range.

Note **CAL port assignments are based on a pressure range, NOT 98RK-1 slot assignments.**

Table 2.1
Pneumatic Connector Assignment
98RK-1

Connection	Pressure Scanner Range Input
Cal 1	User defined
Cal 2	10" W.C.; 20" W.C.; ±1 psid, ±1.5 psid
Cal 3	±2.5; ±5 psid
Cal 4	±10; ±15 psid, ±20 psid, ±25 psid
Cal 5	±30; ±45; ±50 psid
Cal 6	±75 psid, ±100 psid
Cal 7	+150; 200; 250; 300 psid
Cal 8	500 psid, 600 psid, 650 psid, 750 psid, 850 psid

2.3.4.4 PURGE Mode Inputs

9816 scanners are supplied with a *purge/leak-charge* feature. The purge feature allows users to apply positive pressure to the **PURGE** input which will then be vented out of the user input ports, forcing contaminants (such as moisture) out of the pneumatic input lines. **(Note: on common reference 9816 scanners, only the numbered input ports will be purged. RUN REF is not purged).** True differential 9816 scanners will purge both the run and reference input ports for all channels. The purge supply provided to the 9816 must always be a higher pressure than the highest pressure present on the input ports of the module. The purge supply must also be capable of maintaining proper purge pressure at the high flow rates encountered while the module is in the purge mode.

WARNING: Failure to provide proper purge supply pressure may result in migration of moisture and contaminants into the 9816 module. This can result in permanent damage to module components.

When commanded into the **PURGE** position, the purge input pressure will be connected to the numbered measurement input ports allowing for a flow of air away from the instrument. The purge cycle should be terminated by commanding the 9816 into a non-purge mode, such as **CAL**.

WARNING: Purge cycles should NEVER be terminated by turning off the purge supply air while in the PURGE position.

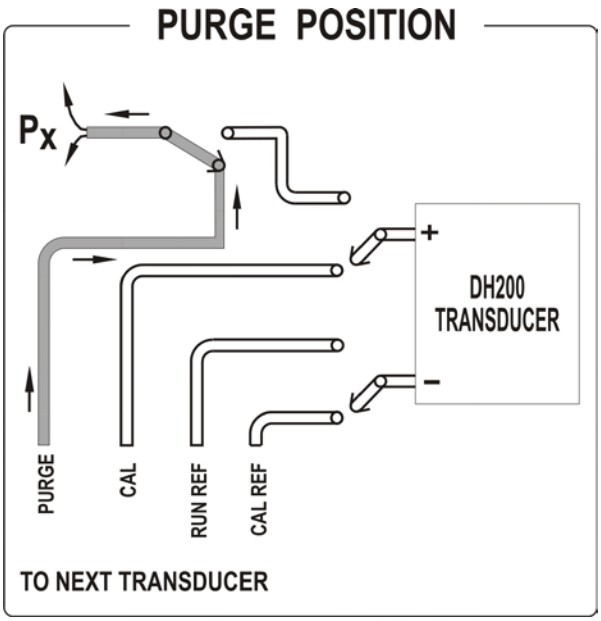


Figure 2.6

2.3.4.5 LEAK Mode Inputs

The purge/leak-charge valve design includes a leak check feature capable of testing the integrity of user pneumatic connections as well as those within the 9816 module. For the leak mode to be used, all **RUN** mode pressure inputs must be dead-ended (closed) by the user. (Contact the MEAS Sales Department for availability of an external leak check valve) When the 9816 is commanded into the **LEAK/CHARGE** position, the **CAL 1-8** input ports will be pneumatically connected to the module run side inputs. Common reference modules will connect only the numbered run side inputs to **CAL** (**RUN REF** is not charged). True differential (reference per port) modules will connect both the measurement input and reference port to **CAL**. While in the **LEAK** position, a test pressure may be applied thought the **CAL** port which will charge the dead-ended run side tubulation.

Note **Test pressures applied to the CAL port during leak check operation must not exceed the full scale pressure of any internal transducer.**

Once the lines are charged, the 9816 may be commanded back to the **RUN** position. This will reattach the charged run side lines to their corresponding internal transducer. Consecutive pressure readings from the 9816 will now allow user to determine the line leak rates. (Factory testing allows a maximum leak rate of 2% in two (2) minutes.) Once returned to the **RUN** position, lack of pressure indicates a gross leak. A slowly declining pressure indicates a slight leak. A leak is more difficult to detect as tubing volume increases. In the case of true differential units where both sides of the sensor are pressurized with the leak test pressure, an initial differential pressure of ***0.0 psi*** should be measured when the unit is placed in the **RUN** position. If the measurement or **RUN** side of the channel leaks at a rate greater than the reference side, a resulting negative differential pressure will be measured. Likewise, if the reference port tubing leaks at a rate greater than the measurement side, a resulting positive differential pressure will be measured.

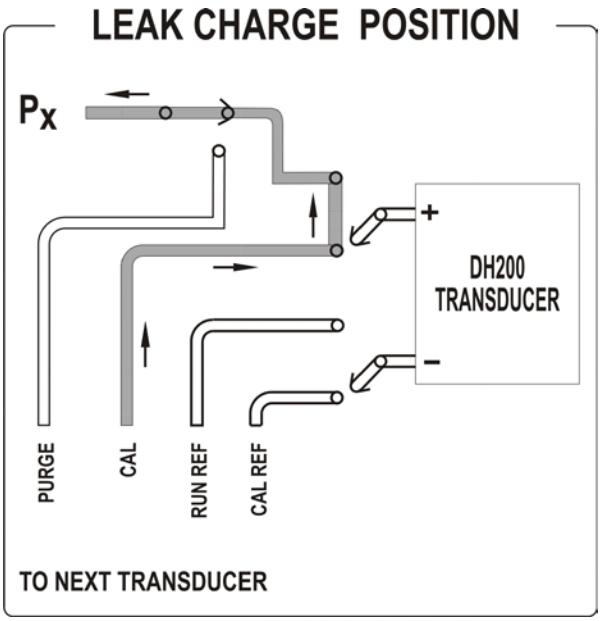


Figure 2.7

2.3.4.6 Calibration Manifold Position Detector Circuit

The transducer calibration manifold position detector circuit uses reflective infrared sensors to sense the *actual* position of the manifold valve block. The block, located within the valve assembly, is shifted to a desired position by pneumatic pistons positioned around the block.

Two reflective infrared sensors, which sense the position of the block by the reflection of the sensor infrared beam from the block surface, are mounted into the assembly. If the block is in front of the sensor, a low level logic signal is output by the sensor, indicating the presence of the block. If the block is not in front of the sensor, the infrared beam is not reflected and the sensor outputs a logic high signal.

Outputs of these sensors are routed to the PC-299 microprocessor board and then to the **CAL** and purge (**PRG**) LEDs on the front of the module chassis. The following table shows the position of the transducer calibration manifold assembly corresponding to front panel LED illumination.

LED INDICATORS		
VALVE POSITION	**CAL**	**PRG**
RUN	**OFF**	**OFF**
CAL	**ON**	**OFF**
PURGE	**ON**	**ON**
LEAK/CHARGE	**OFF**	**ON**

2.3.5 Cluster, Rack, and Slot Identification

The **98RK-1 Scanner Interface Rack** can operate as a single unit, with one (1) to eight (8) pressure scanners installed in each rack. Racks may also be grouped together as a *cluster* of racks as part of a larger data acquisition system.

In order to physically identify individual scanners within a data acquisition system, a simple addressing scheme is available. Individual scanners are identified by their *Cluster, Rack,* and *Slot* (CRS) address, a three-digit hexadecimal number.

A *cluster* (the most significant address unit), is numbered 0-F (hex), for a total of 16 clusters of racks.

A *rack* (the middle address digit), may be numbered 0-15, for a total of 16 racks. (NOTE: The switch for setting the *rack* address is numbered in integers, but the address is returned in hex — 0-F.)

A *slot* (the least significant address unit), numbered 1 through 8, designates a particular 9816 pressure scanner.

The diagram on the following page depicts the 98RK-1 Scanner Interface Rack front pullout panel with switches identified for setting *Cluster* and *Rack* addresses. *Cluster* and *Rack* addresses may be set at any number (user option) as long as it falls within the range of the

switch settings. (*Slot* addresses are automatically set by their specific physical presence within the rack.)

The *cluster* address is set via a slotted screwdriver-adjustable hexadecimal switch on the PC-293 (Ethernet Controller board), located in the pull-out slide tray (front panel of the 98RK-1). *Cluster* address settings are 0 through F (a total of 16). In the illustration, the hexadecimal switch is annotated.

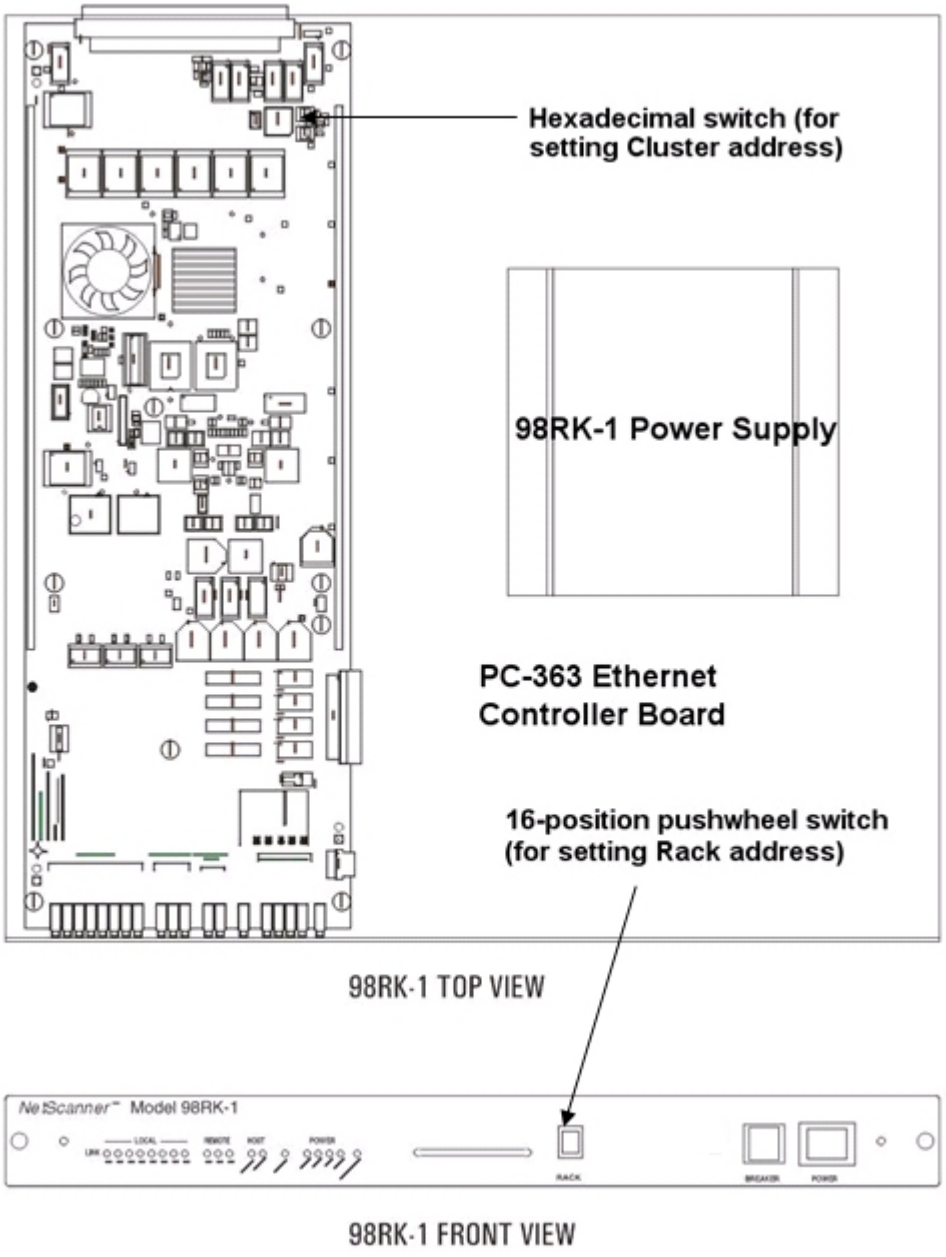

Hexadecimal switch (for setting Cluster address)
98RK-1 Power Supply
PC-363 Ethernet Controller Board
16-position pushwheel switch (for setting Rack address)
98RK-1 TOP VIEW
NetScanner™ Model 98RK-1
98RK-1 FRONT VIEW

Figure 2.8
98RK-1 Front Pull-out Tray Diagram
Top and Front Views

The *rack* address is set via a 16-position (0 through 15) push wheel switch, located on the front panel of the 98RK-1.

The *slot* addresses are numbered 1 through 8, starting from the leftmost slot in the 98RK-1 and each scanner's address is fixed by its physical presence in the rack.
The following illustration shows how a typical CRS addressing system would identify a particular scanner:

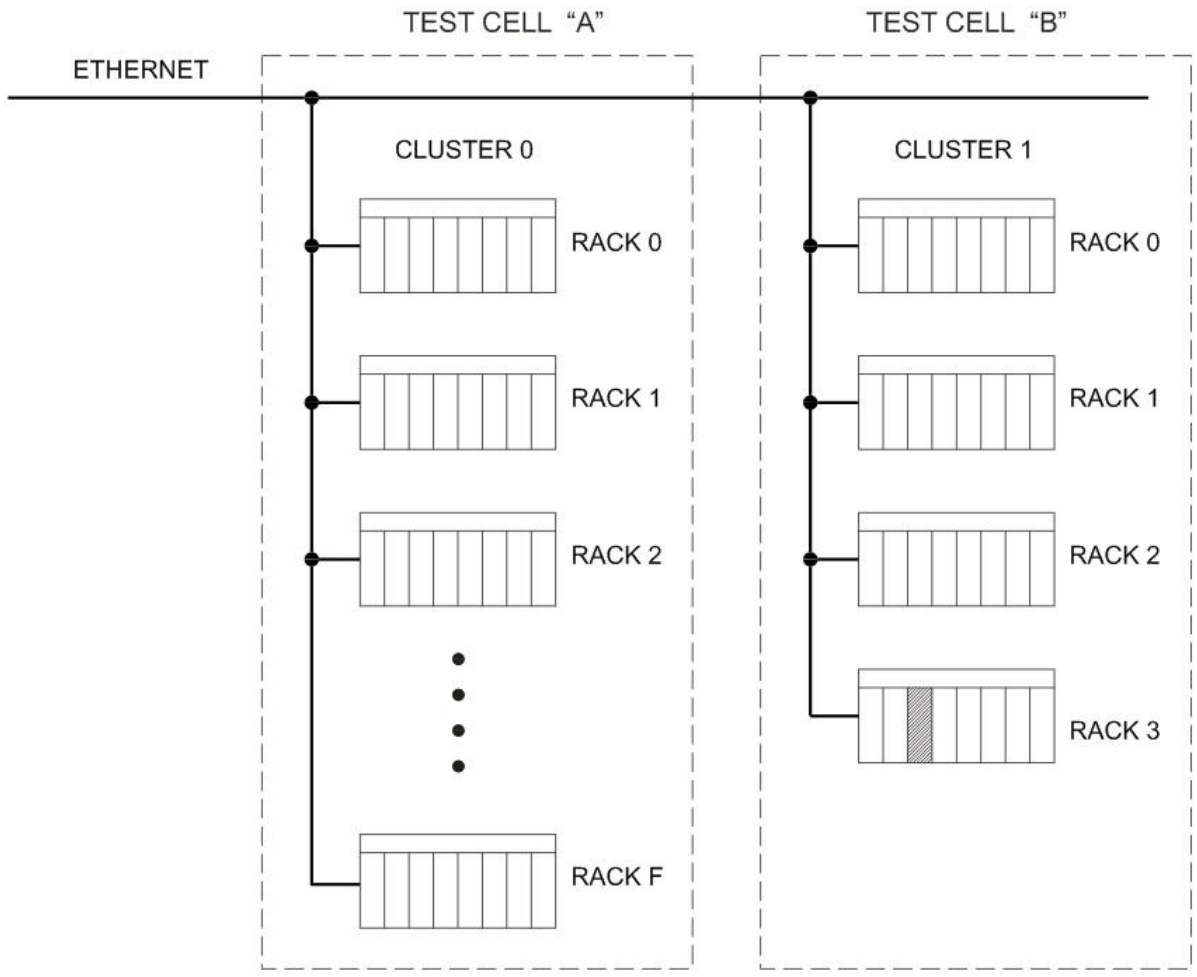


Figure 2.9
Typical Depiction of C-R-S Scanner Identification

In the above depicted array, the CRS address of the shaded scanner would be **133**, *cluster* 1, *rack* 3 and *slot* 3.

2.4 Acquiring Data

STEP 20	From the Acquire menu, select "Acquire Data" to read the pressure of each channel on the screen. The pressure is displayed both in engineering units and on the individual bar graphs as a proportion of transducer full scale.

STEP 21	To log data, select "Log." A file name will be requested with an automatic path to the **NUSS** directory. Click "Cancel" to display the data on the screen. While logging, the data is displayed on the logging screen in engineering units. To stop logging, select "Stop."

STEP 22	To stop data acquisition and freeze the display at the last reading, select "Stop Acq." from the "Acquire Data" menu.

STEP 23	Select Re-zero from the Calibration menu. This will perform a Re-zero calibration and report the amount of offset which has automatically been corrected (relative to the factory calibration stored within each transducer).

STEP 24	The temperature of each transducer can also be displayed in units of degrees Celsius (ºC) by selecting Acq. Temp. Each transducer has an integral temperature sensor used primarily for the digital temperature compensation which is performed automatically.

Reading the temperature is most useful when verifying that you are operating within the calibrated temperature range. The 9816 modules will update this value once every 15 seconds.

You have accomplished all of the steps in this manual for quickly getting a single **NetScanner™ System** module up, running, and acquiring data. To similarly test another module in the rack (or externally attached), use the "Next Module" menu command.

Chapter 3

Programming and Operation

3.1 Commands & Responses

3.1.1 Introduction

This chapter describes all *commands* a host computer program may send to each of the **NetScanner™ System** Intelligent Pressure Scanner modules **(Model 9816**) that are connected to the various slots of the **98RK-1 Scanner Interface Rack** chassis, as well as the data or status *responses* returned by these modules. Some of the commands are similar to those for other **NetScanner™ System** models (e.g., 903x, 9016/9116 or 9021/9022) that may be externally attached to the **98RK-1** chassis. However, refer to their appropriate users' manuals since some commands are model-specific. Most applications require working knowledge of only a small number of commands.

Each internal **Model 9816** pressure scanner module (mounted in **98RK-1** chassis slots) has an Ethernet interface and uses layered TCP/UDP/IP transmission protocols to communicate with a host computer. These same protocols (and Ethernet interface) are also used for any externally-connected scanner or standard/calibrator modules (connected to the 98RK-1 chassis rear connectors). These modules are all "networked" together (with a host computer) via the 12-port Ethernet gigabit switch (inside the **98RK-1** chassis).

All commands/responses to and from **NetScanner™ System** modules are embedded in the data fields of either a TCP or UDP packet header. In turn, these packets are themselves embedded in the data field of an IP packet header — which is embedded in the data field of an Ethernet packet header. Thus, the term *layered* protocols.

3.1.2 TCP/UDP/IP Protocols

TCP/UDP/IP protocols are a well-established set of rules for communicating over a network (LAN, intranet, or internet), and are independent of the network's physical medium. The **Model 9816** uses the TCP/IP protocols for most commands and responses since the TCP layer provides a robust error detection and correction mechanism, but requires the establishment of a formal connection between host and module. The simpler UDP layer, requiring no formal connection, is utilized for a few simple commands and a query response.

Using the underlying basic IP protocol, the host computer and interconnected modules are all "peers" that can all communicate equally. Each "peer" must have a unique "logical" *IP Address* (as well as its own unique "physical" *Ethernet Address*) to be directly addressed. Any "peer" may initiate transmissions without permission from the receiver. In **NetScanner™ System** implementation, the host computer is normally a *client* and generally initiates most

transmissions by sending commands to the modules, which are normally *servers*. However, a module can initiate its own transmissions in some operating modes (e.g., the *hardware-triggered* or *free-run* autonomous *host streams* generated by the ***Configure/Control Autonomous Host Streams*** (**'c'**) command). A maximum of 255 modules are easily addressed by varying only the low-order byte of a typical IP Address. Many more modules may be addressed by also changing the "network" portion (high-order 3 bytes) of the IP address.

A "peer" may be directly addressed by its IP address (in xxx.xxx.xxx.xxx format) or by use of a predefined *logical name* that allows its *IP Address* to be looked-up in the sender's database or in a central network server's database. Windows®-based operating systems provide a simple text file database called "Hosts." Review the file "Hosts.sam" in the "C:\windows" directory. Modify and rename it "Hosts." (no file extension) to activate it.

Before the host computer and any module can communicate with the higher level TCP/IP protocols, the host (*client*) must request a *connection* be established with the module (*server*). Each module expects all such requests for *connection* to be requested by its *IP Address*, and directed to "well-known" port 9000 (default). After the connection is made, a *socket* is established as a logical handle to this connection. The host and module may then communicate, via this *socket,* until it is closed (or is lost at either module or host end, due to power failure or reboot). The host and module may also communicate in a limited fashion *without a connection*, using the middle-level UDP/IP protocols. In that case, the host simply broadcasts commands via port 7000, and each module (that chooses to respond) returns the response on port 7001. Only a few commands use UDP/IP in **NetScanner™ System** modules.

3.1.3 Commands

The commands (and responses) used by all **Model 9816** modules consist of short strings of ASCII characters. The TCP/UDP/IP protocols allow for the transfer of either printable ASCII characters or binary data. When using certain formats, internal binary data values are often converted to ASCII-hex digit strings externally. Such values may include the ASCII number characters '0' through '9', the *uppercase* ASCII characters 'A' through 'F', and the *lowercase* ASCII characters 'a' through 'f.' These hex values may represent bit maps of individual options, or actual internal integer or floating point (IEEE) binary data values. In other cases (see optional *format 7* below), binary data may be transmitted directly as 4-byte (32-bit) big-endian binary values without any formatting change.

3.1.3.1 General Command Format

A typical TCP/IP command (contained in the data field following a TCP packet header) is a variable-length character string with the following general fields:

- a 1-character *command letter (c)*,
- an optional *position* field *(ppppp)*, a variable length string of hexadecimal digits,
- a variable number of optional *datum* fields (*dddd*): each a variable length string, *normally* formatted as a decimal number (with a leading *space* character, and with or without *sign* and/or *decimal point,* as needed).

Using brackets *([*]) to show optional elements, and ellipsis (...) to show indefinite repetition, a typical TCP/IP command may be viewed schematically as follows:

"*c*[[[[[*p*]*p*]*p*]*p*]*p*][*dddd*[*dddd*]...]"

From this schematic, it should be clear that the *command letter* (c) is required, the *position* field *(ppppp)* immediately follows it, and may have 0, 1, 2, 3, 4, or 5 characters, and there may be zero or more *datum* fields *(dddd),* as required. For simplicity, the variable length nature of *each* "*dddd*" string is not shown [with brackets] above, but the required leading space character is shown. The *position* field is similarly simplified (as *"ppppp")* below.

A typical UDP/IP command (contained in the data field following a UDP packet header) is also a variable length character string, but has a simpler format. Generally, it has a variable length *command string (cccccc)*, followed by one optional *datum (dddd)* field (preceded by one *space* character):

"cccccc[*dddd*]*"*

Since there are only a few simple UDP/IP commands, all references to *commands* below should assume TCP/IP commands, unless otherwise indicated.

3.1.3.2 Command Field

All **NetScanner™ System** models recognize a set of predefined commands. Most are TCP/IP commands having only a single alphabetic letter for a *command* field. These are recognized only when a formal *socket* connection is established with the host computer. A few are UDP/IP commands with a longer *command* field. These are recognized anytime the module has power applied. All commands are functionally summarized in the following sections and detailed in reference **Section 3.2.**

3.1.3.3 Position Field

For some commands, the *position* field *(ppppp)* may be broken into other distinct independent subfields (e.g., *xxyyzzf*) and these subfields may or may not relate to any *datum* fields. In other commands, there may be a 1-to-1 correspondence between '1' bits in the *position* field (viewed as a binary bit map expressed as a hex number) and the number of *datum* fields that follow it (or the number of *datum* fields returned in the command's response). The bit map form is explained below.

All **NetScanner™ System** (**Model 9816**) Intelligent Pressure Scanner models may contain a maximum of sixteen (16) internal and two (2) external (rack) input channels. When commands affect *certain channels* scanned by the module, the *position field* is used to identify those channels as bits in a bit map. If a channel's corresponding bit in the *position* field is set to a one (1), then that channel is affected by the command. The least-significant (rightmost) bit 0 corresponds to Channel 1, and the most significant (leftmost) bit 15 corresponds to the highest internal Channel 16. Special external (98RK-1 rack) channels, that a Model 9816 can also scan, require two additional bits (in one more 4-bit hex digit in the bit map *shown highlighted below*). Bit 16 (Channel S) specifies the 98RK-1 rack's *source air* transducer and Bit 17 (Channel P) specifies the *purge* transducer. Bits 18 and 19 will remain unused (must be=0) unless they become defined in a future software release.

In the following example 20-bit (5-hex digit) position field, internal channels 16 and 1, and both external *P & S* pressures, are selected:

Bit#	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Chan#			P	S	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Binary	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hex	3				8				0				0				1			

When all applicable *internal* channel bits are set in the *position field* (i.e., FFFF for a 16-channel 9816 module), it specifies *all internal channels*. Alternately, some commands allow a *missing position field* to designate *all internal channels*, but only when there are no other parameters following the *position field* in the command. Optionally, the hex *position field* may be reduced from 5 to 4 digits when no external (P & S) channel bits need be set (=1) in the ***discarded high-order*** hex digit). In two commands (**'C'** and **'c'**), only the position field may have 1-5 digits, as needed, to specify progressively higher numbered channels.

Note

A *position* field bit map may specify the number and order of *datum* data from module). In either case, the order of the *datum* fields is from highest requested channel number to lowest requested channel number.

3.1.3.4 Datum Fields

Any *datum* fields in a command generally contain data to be sent to the module, usually specified by a *position* field bit map. In some commands (when data are to be received from a module instead) no datum fields are required in the command itself, but the *position* field bit map is still used to specify the order that data are returned in the command's response. In either case, the order bits are set (to 1) in the *position* field bit map (highest channel # to lowest channel #, left to right) is the order these datum fields are received or sent. The special *external* P & S channels are considered *higher #'s* than any *internal* channels #'s (16-1).

Each *datum* field may be variable in length, whether part of the command itself or the command's response. In its most common format, a *datum* begins with a *space* character (' '), and is followed by an optional sign, decimal digits, and decimal point, as needed (e.g., -*vv.vvvvvv*). For other formats it may be a hex digit string or pure binary number.

3.1.3.5 Format Field

Some commands, that either send data to a module (as command parameters), or cause the host to receive data (via command's response), have an extra *format* parameter *(f* digit) appended to (or specified in) the *position* field. This parameter, when specified (or implied by default), governs how internal data are converted to/from external (user-visible) form.

- The most common format (*f=0)* causes each datum (in command or response) to be a decimal number externally (with optional *sign* and *decimal point* as needed). Internally, the module sets/obtains each converted datum to/from a single binary (32-bit) IEEE float.

- Some formats (*f*=1, 2, 5) encode/decode the internal binary format to/from ASCII hexadecimal external form. Some of these "hex dump" formats provide an external hex bit map of the internal binary value (float or integer as appropriate). Format 5 may encode/decode the internal float value to/from an *intermediate* scaled binary integer (e.g., float value * 1000 into integer, then to/from a hex bit map).

- Two special "binary dump" formats (*f*=7 and *f*=8) may be used by some commands to accept/return binary data directly from/to the user's command/response. Such values are not user-readable in their external form, but provide highly compact storage without any accuracy loss due to formatting. Use of these formats allows both the module and host program to operate at their most efficient low overhead. Format 7 returns the most significant byte first (i.e., *big endian*). Format 8 returns the least significant byte first (i.e., *little endian*).

See the individual command descriptions for the formats a particular command recognizes.

3.1.4 Responses

Four (4) types of responses can be returned from a 9816 **NetScanner™ System** Intelligent Pressure Scanner module:

- an ***Error*** response,
- an ***Acknowledge*** response,
- an ***Acknowledge with Data*** response, or
- a Network Query response.

The first three may be returned by TCP/IP commands, the latter from a UDP/IP command.

The error response consists of the letter 'N' (for NAK, or negative acknowledge), followed by a 2-digit hexadecimal error code. The following table lists the error codes that can be returned from a 9816 **NetScanner™ System** module:

CODE	MEANING
00	(Unused)
01	Undefined Command Received
02	Unused (by TCP/IP)
03	Input Buffer Overrun
04	Invalid ASCII Character Received
05	Data Field Error
06	Unused (by TCP/IP)
07	Specified Limits Invalid
08	NetScanner error: invalid parameter
09	Insufficient source air to shift calibration valve
0A	Calibration valve not in requested position

The *Acknowledge* response is returned from a module when a command is received that requires no data to be returned, and no error is detected. It indicates successful parsing and execution of the last received command. It consists of the letter 'A' (for ACK, or acknowledge).

The *Acknowledge with Data* response is returned when a module receives a command requesting data. Model 9816 modules will typically return only the requested data values, each preceded by a space character (except for format 7). No **'A'** (acknowledge) letter begins this data response. **Data are returned for the highest requested channel number first. Data for lower requested channels follow in reverse order (e.g., P&S, then 16-1).**

3.1.4.1 Interpreting Offset Values (Re-zero Calibration Adjustment)

When a **Model 9816** module is instructed to execute the command ***Calculate and Set Offsets*** (**'h'**), a datum corresponding to the calculated ***offset correction*** term (or coefficient) is returned for each affected channel. Each such coefficient value is stored internally, and will be subtracted in all subsequently calculated data conversions, to correct for zero drift effects. The command only returns them in the response (in current engineering units (EU) of pressure near 0.0) to allow the user to make reasonableness checks on them. The ***Read Internal Coefficients*** (**'u'**) command will return them on demand.

3.1.4.2 Interpreting Gain Values (Span Calibration Adjustment)

When a **Model 9816** module is instructed to execute the command ***Calculate and Set Gains*** (**'Z'**), a datum corresponding to the calculated ***gain correction*** term (or coefficient) is returned for each affected channel. Like the *offset* coefficient, each *gain* coefficient is stored internally, and will be used in all subsequently calculated data conversions, to correct for gain change effects. The command returns them in the response (as a unitless factor near 1.0) to allow the

user to make reasonableness checks on them. The ***Read Internal Coefficients*** (**'u'**) command will return them on demand.

3.1.4.3 Interpreting Engineering Units Output

All **Model 9816** modules perform all internal pressure calculations in engineering units (EU) of pounds per square inch (psi). By default, all pressure data in responses and command parameters will also be in psi. A different engineering unit (e.g., kPa) may be obtained by changing an internal **EU Pressure Conversion Scaler** (normally 1.0). See the "***Read/Download Internal Coefficients***" **('u'/'v')** commands (array 11, coefficient 01).

3.1.5 Functional Command Overview

The various **NetScanner™ System** commands for 9816 modules are best introduced by classifying them into functional groups and then describing how each function is carried out in a typical system. The following functions are defined for this purpose:

- Start-up Initialization
- Scan List Definition for Acquisition
- Calibration Adjustment of Engineering Unit *Correction* Coefficients
- Acquisition/Delivery of Data to Host
- Network Query and Control

Please look ahead to **Table 3.1**, labeled **9816 NetScanner™ System Commands**, in **Section 3.2**, for a quick-look summary of all commands available to the Model 9816 module. Each command may be referenced by both its *functional title* and by its *command id* in the functional discussion sub-sections below.

The **Detailed Command Description Reference** immediately follows the table in **Section 3.2**, with each command description occupying a page (or more if necessary). Command descriptions in this section (as in the table) are ordered first by *type* (TCP/IP then UDP/IP), then by *"command id"* in *ASCII order* (*UPPERCASE* letters (***A .. Z***) first, then *lowercase* letters (***a .. z***)).

3.1.5.1 Start-up Initialization

Since power supplies may be distributed widely across a network of modules and host computer(s), it is not uncommon for modules (singly or together) and the host to lose power independently. Thus, their power may be restored at different times. Start-up initialization for every module must normally be performed when its power is restored, as each module enters default states after power-up, which may not be the state the host computer had previously been operating in. Any previous TCP/IP socket connection is also lost after power failure and must be re-established between host and module before any TCP/IP commands can be recognized by the module. These commands are generally used to *detect* that start-up initialization has occurred (or to force reset at other times), after which other commands may be used to restore the original operating condition.

In the **NetScanner™ System** (using the **98RK-1 Scanner Interface Rack**), the **Power-Up Clear** (**'A'**) command may be used as a simple command to elicit a known response from a module. Although this causes no internal function within the module, it will result in an acknowledgment being returned to the host computer to verify proper communications. The best way to detect

that a power reset has occurred in a module is to notice that the TCP/IP socket connection is no longer valid. At any point during module operation, the ***Reset*** (**'B'**) command may be used to return any module to its default "reset" state. If the module is then required to enter any other states (that were previously programmed for it by the host), the host must then restore these states accordingly using the appropriate commands. This reset command simply returns internal software parameters to a default state (as after power up or reboot). It will not close the existing TCP/IP socket (as will power up or reboot).

The **Set/Do Operating Options/Functions** (**'w'**) command has many purposes, but may first be utilized during the module initialization stage. It may also be executed at any time during data acquisition. However, some non-factory-default options of **'w'** may become the new reset default, if a particular function is used to establish them in non-volatile memory.

If any form of the **Configure/Control Autonomous Host Streams ('c')** command or the **Configure/Control Multi-Point Calibration** (**'C'**) command was in use before reset, it must be executed again after the reset to restore it. Any other command, that establishes the module in a *non-default reset state,* must be re-executed after a reset, if processing is to continue in that state.

The **Network Query** ("psi9000") UDP/IP command may be used (at any time) to make each **NetScanner™ System** module on the network identify itself to the host(s). A parameter, returned in each module's response, indicates whether or not a module still has a valid connection. This is a useful way to detect if an overt *reset* occurs in a module. The module may be configured to emit this response *automatically* after any reset (power on or reboot).

3.1.5.2 Module Data Acquisition

After power-up, all **NetScanner™ System** modules will begin to scan all internal channels in channel number order (16 to 1). Scanning will occur at the module's maximum internal rate (using the previously stored *number of data averages per channel*). Special external rack (P & S) channels of the 9816 module are also scanned, but less frequently. The data are stored in an internal buffer, available for retrieval by the host computer. Engineering units conversion of the scanned channels is accomplished (in a separate internal buffer) using thermal correction data extracted from each transducer at power-up. While scanning, the module will automatically monitor the attached transducers' temperatures, correcting engineering unit output for any temperature effects.

All **NetScanner™ System** models effectively defer the host computer's decision of "which channels of data do I want" until the host chooses to send *read* commands to actually retrieve the desired data from the latest "buffered copy" of the continuously scanned, averaged, and engineering-unit-converted data. See **Section 3.1.5.4** (**Delivery of Acquired Data to Host**) below for more details.

While scanning, all modules take multiple samples and average each channel. The *number of samples per internal channel* defaults to 8 (eight), but may be set to 1 (one) to disable averaging altogether, or set to any suitable higher value to change the degree of averaging (and its effect on maximum scan rate). The **Set Operating Options** (**'w'**) command may change this variable at any time. The same command may be used to store the new averaging value as the module's reset default.

3.1.5.3 Calibration Adjustment of Offset/Gain Correction Coefficients

All **NetScanner™ System** Intelligent Pressure Scanners have built-in software commands (and pneumatic hardware) to perform a periodic *zero* and *span* calibration *adjustment* of its internal or attached pressure transducers. Use of these periodic adjustments result in the highest possible data accuracy. The result of these calibrations is a new set of internal *offset* and *gain* coefficients. These *correction* coefficients are over and above those factory-determined and *unchanging* thermal correction coefficients stored in each transducer's non-volatile memory. The factory coefficients provide basic engineering unit conversion capability, while also correcting for various non-linear effects, including temperature effect compensation. The *offset* and *gain* correction coefficients provide for fine "linear fit" adjustment of the factory calibration of each transducer. **If used properly, the periodic zero and span calibration adjustment should be the only calibration required to maintain specified performance throughout the life of the Intelligent Pressure Scanner.**

It is generally necessary for the transducer to have real "zero" and "span" pressure points (specified as 2 or more values) applied when calibration adjustment is required These pressure values may be generated by secondary pressure standards, such as the Model 903x calibrator module or by other external means provided by the customer (such as a dead weight calibrator). For the more common zero-only calibration adjustment, zero differential pressures can typically be provided without the need for external pressure generators. All 9816 models have built-in pneumatic inputs (CAL side inputs) and calibration manifolds required for directing the generated pressures to the various channels of the module(s) being calibrated. **Refer to Chapter 4 of this manual for detailed background and procedures for periodic calibration of the Intelligent Pressure Scanners.** A summary of the commands used for calibration purposes is included below.

The **Calculate and Set Offsets** (**'h'**) command is executed only when a suitable "minimum" (e.g., zero) pressure has been applied to all channels of the module. The new *offset* coefficients that result from execution of this command are stored in the module's volatile (or temporary) engineering-unit conversion database. They are also returned to the host in the command's response.

The **Calculate and Set Gains** (**'Z'**) command should be executed only when "full-scale" (or other suitable specified up-scale) pressure has been applied to the appropriate channels of a module. The new *gain* coefficients that result from this command are stored in the module's volatile (or temporary) engineering-unit conversion database. They are also returned to the host in the command's response.

In modules using firmware version 2.24 or later, a **Configure/Control Multi-Point Calibration** (**'C'**) command is provided. This command (actually 4 sub-commands) is an improvement over the single calibration commands (**'h'** and **'Z'**) described above. Though **'C'** provides for the *adjustment* of the same *offset* and *gain* correction coefficients already described above, it does so with two **or more** applied pressure calibration points. The final linear fit (i.e., new *offset* and *gain* correction coefficients) is a "least squares" correction fit between all the calibration points specified. This **'C'** command is particularly useful in calibrating differential transducers over their entire negative-to-positive range.

Although the calculated *offset* and *gain* correction coefficients simply remain in volatile memory following execution of the calibration commands (for use by all subsequent EU conversions), they may be optionally stored in non-volatile transducer memory with the **Set Operating Options** (**'w'**) command (Index 08 and 09).

The above correction coefficients are maintained internally in IEEE floating-point format. The **Read Internal Coefficients** (**'u'**) command and the **Download Internal Coefficients** (**'v'**) command can return (or manually set) calibration coefficients to the host in decimal or hex dump formats in their responses.

3.1.5.4 Delivery of Acquired Data to Host

Several commands apply to host delivery of acquired data, either *on demand* or *autonomously*. For all Ethernet models, the Read **High Precision Data** (**'r'**) command may be used to obtain high precision data (in various formats). In addition, Model 9816 provides several high speed, high resolution output commands. The **Read High-Speed Data** (**'b'**) command is used to read "pure binary" engineering unit pressure (all 16 channels are returned in the lowest overhead format). Use the **'r'** and **'b'** commands to get acquired data *on demand*.

The module can also deliver EU *pressure* data in *streams,* which consist of TCP/IP data packets that arrive *autonomously* in the host (with data from *selected* channels being delivered in various formats at various rates). Up to three independent *streams (or time classes)* may be configured, started, stopped, and cleared with the **Configure/Control Autonomous Host Streams** (**'c'**) command. In conjunction with *hardware triggering*, this *autonomous* delivery method can also make the module *acquire* (as well as deliver) data in its most efficient and time-synchronized manner. This also frees the host to receive/process/record these data in its most efficient manner, since it need not waste time continually requesting new data.

Model 9816 also has special purpose *on demand* data acquisition commands, including: **Read Transducer Voltages** (**'V'**) and **Read Transducer Raw A/D Counts** (**'a'**), which provide two views of raw *pressure* data. It has similar commands providing EU temperature (□C) and other raw views of each channel's special *temperature* signal, including **Read Transducer Temperatures** (**'t'**), **Read Temperature A/D Counts** (**'m'**), and **Read Temperature Voltages** (**'n'**). This command group is generally used for diagnostic purposes. All of these special purpose data (plus other module status information) may also be periodically delivered to the host automatically in any of the three flexible *autonomous streams* configured by the **'c'** command.

3.1.5.5 Network Query and Control Functions

A special subset of three (3) UDP/IP commands may be sent to a module at any time power is applied to it (i.e., neither a host socket connection nor a unique IP Address assignment is required). Each such command is *broadcast* to all modules (i.e., sent to IP Address 255.255.255.255) via Port 7000, and any module wishing to respond will return a response via Port 7001.

Only one of these commands returns a response. This is the **Network Query ('psi9000')** command. The others cause the module to be re-booted, therefore no response is possible. One command changes the way the module gets its IP address assignment (i.e., dynamically from a server or statically from factory-set internal data).

3.1.5.6 Other Functions

Some commands may be used at any time to obtain information about the internal setup and status of a module. The **Read Module Status** (**'q'**) command is an example. Also, the **Set Operating Options** (**'w'**) command, though generally used after power-up reset, may also be used at other times as well to change system operation. The actual *feedback position status* of internal *valves,* and several *temperature status* conditions, may be configured to be periodically delivered to the host automatically in any of the three *autonomous streams* configured by the **'c'** command.

3.2 Detailed Command Description Reference

All commands applicable to the Model 9816 **NetScanner™ System** models are described on the following pages and summarized in the following table.

Table 3.1
Model 9816 NetScanner™ System Commands

type	command id	function
TCP/IP Commands	**A**	**Power-up Clear**
	B	**Reset**
	C	**Configure/Control Multi-Point Calibration** (4 sub-commands)
	V	**Read Transducer Voltages**
	Z	**Calculate and Set Gains** (Span Cal)
	a	**Read Transducer Raw A/D Counts**
	b	**Read High Speed Data**
	c	**Configure/Control Autonomous Host Streams** (6 sub-commands)
	h	**Calculate and Set Offsets** (Re-zero Cal)
	m	**Read Temperature A/D Counts**
	n	**Read Temperature Voltage**
	q	**Read Module Status**
	r	**Read High Precision Data**
	t	**Read Transducer Temperature**
	u	**Read Internal Coefficients**
	v	**Download Internal Coefficients**
	w	**Set/Do Operating Options/Functions**
UDP/IP Commands	**psi9000**	**Query Network**
	psireboot	**Reboot Specified Module**
	psirarp	**Change Specified Module's IP Address Resolution Method (then Reboot)**

Refer to the particular user's manuals for other (externally connected) 9016/9116, 9021/9022, and 903x models for their specific commands.

POWER UP CLEAR (Command 'A')

Purpose: This command has no internal module affect. It is used as a simple method to verify proper communications to the 9816 scanner.

Command	"**A**" 'A' is the *command letter*
Response	"**A**" 'A' is the *acknowledge* letter

Description: The Ethernet **Model 9816** does not return a 'Power-Up Clear Expected' error (as did early 901x modules without Ethernet interface). This is due to the reset notification mechanisms that are part of the TCP/IP protocol. It is generally used as a simple 'NOP' mechanism to verify proper communications with a module.

Example:

- Send TCP/IP command to Model 9816 module (via its open socket) to acknowledge module power on:

  "A"

  Read following response:

  "A"

RESET (Command 'B')

Purpose: Instructs the module to reset internal operating parameters, and to set all internal control variables to their default "reset" state (see description below). The current TCP/IP socket connection will remain open. Execution after a power off/on cycle is optional (unnecessary).

Command	"**B**" 'B' is the *command* letter
Response	"**A**" 'A' is the *acknowledge* letter

Description: The module returns to the following "reset" states if this command is executed:

- Re-zero correction (offset) terms are set to the last values stored in transducer memory.
- Span correction (gain) terms are set to the last values stored in transducer memory.
- Calibration Valve is set to the RUN Position.
- Number of Samples for Data Averaging is set to last value stored in non-volatile memory (factory default = 8).
- Any *autonomous* host data delivery *streams* defined by **'c'** sub-commands are reset (undefined).
- The *Multi-Point Calibration* function defined by **'C'** sub-commands is reset (undefined) if in progress.

Example:

- Send TCP/IP command to a **Model 9816** module (via open socket) to reset defaults:

  "**B**"

  Read following response:

  "A"

CONFIGURE/CONTROL MULTI-POINT CALIBRATION (Command 'C')

Purpose: This *command* is actually *four (4) sub-commands*. The *first* configures and starts a **Multi-Point Calibration** adjustment function for selected channels in the module. *Another* is repeated multiple times to collect data for each defined calibration point. *Another* ends the calibration function normally by calculating new *offset* and *gain* adjustment coefficients from the collected data. It then returns the module to its normal state, but with improved accuracy. A *final* sub-command is used only if it becomes necessary to *abort* the calibration function while in progress. The *general form* of all sub-commands is described in the table below. Subsequent pages separately describe *each individual sub-command* and give examples of each.

Note **This 'C' command (with sub-commands) is available only in modules that have upgraded to firmware Version 2.24 or later.**

Command	"**C *ii*[*dddd*]...** " 'C' is the *command* letter. ' *ii*' is a required *sub-command* index preceded by a *space* character. ' *dddd*' are zero or more optional *datum* (or parameter) fields, each preceded by a *space* character. These vary with the sub-command used.
Response	Depends upon the particular sub-command (*ii*) used.

Description: The four **'C'** sub-commands configure and control operation of a **Multi-Point Calibration** function that is similar to the simpler *re-zero* and *span* calibration adjustment functions (see separate **'h'** and **'Z'** commands). However, **'C'** adjusts **both** the *offset* and *gain* correction coefficients of each affected transducer at the same time, using two **or more** calibration points. Thus, instead of simply calculating a new linear (i.e., straight line) adjustment function that **passes through** the supplied *zero* and *span* calibration points, it calculates a *best-fit* straight line, using the ***least squares method,*** that **comes "as close as possible" to *all* the supplied calibration points**. This correction method provides the very best adjustment throughout the entire range (negative to positive) of a differential transducer.

Note **Avoid confusing this Calibrate command 'C' (upper case C) with the *Configure/Control Autonomous Host Streams* command 'c' (lower case c). Like 'c', but unlike most other module commands, all sub-commands of this command require a *space* between the *command id* ('C') and its first parameter (*ii*).**

Command 'C'— Sub-command Index 00: Configure & Start Multi-Point Calibration

This sub-command has four (4) additional required parameters used to configure and start the Multi-Point Calibration function.

Command	"**C 00 *pppp npts ord avg***" 'C' is the *command* letter. ' 00' is the *sub-command index* (*ii*) for *Configure & Start*. ' *pppp*' is a 1-4 hex digit *position* field (channel selection bit map), that selects any of the 1-16 *internal channels* to be affected by the multi-point calibration. It **cannot** specify *external channels* P & S. ' *npts*' is the *number of unique calibration points* (between 1 and 19) to be supplied during the calibration function. ' *ord*' is the *order of the adjustment fit*, which currently must be 1 for a 1st order *linear fit* of the calibration data (i.e., a straight line). ' *avg*' is the *number of A/D data samples collected and averaged* for each calibration point supplied (must be a power of 2 in the set 2, 4, 8, 16, 32, or 64) **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter and is returned if all parameters are supplied with reasonable values. Else, an error ('N') response is returned.

Description: Configures and starts the **Multi-Point Calibration** function. It specifies the particular channels (*pppp*) whose *offset* and *span* adjustment coefficients will be replaced when the function is completed. All specified channels must have the **same full-scale pressure range**. Modules with more than one range of internal transducers installed must have channels from each range calibrated separately.

This sub-command immediately alters the module's normal data acquisition process's *A/D samples for average* count (default = 8, or as per the 'w10dd' command) and uses the sub-command's *avg* parameter sample count instead. A larger count (e.g., 64) is encouraged for calibration purposes. The original sample count will not be restored until the calibration function ends or is aborted (per other sub-commands described on the following pages).

The *npts* parameter fixes how many calibration points must be supplied when the **Multi-Point Calibration** function's *data collection phase* starts later with multiple invocations of another sub-command (described below). Currently, only a linear (1st order) fit of the calibration points is available.

Example:

- Configure and start the **Multi-Point Calibration** function so that it affects only the first four (4) channels of the module. Three (3) pressure calibration points will by supplied when we continue this function later (see example for '01' sub-command below). A linear (1st order) fit will be used to obtain a new set of *offset* and *gain* correction coefficients for these four (4) channels. The maximum average sample count (64) is used to collect each calibration data point, so as to minimize any noise in the data samples. The module's data acquisition process is altered immediately to collect the increased number of averages.

  "**C 00 F 3 1 64**"

  Read response:

  "A"

Command 'C'— Sub-command Index 01: Collect Data for a Calibration Point

This sub-command has two (2) additional required parameters.

Command	"**C 01 *pnt pppp.pppp***" 'C' is the *command* letter. ' 01' is the *sub-command index* (*ii*) for *Collect Data* ' *pnt*' identifies a *particular calibration point* that will be supplied. It must be between 1 and *npts*, where *npts* was a parameter of the previously executed *Configure & Start* ('00') sub-command. ' *pppp.pppp*' is the *pressure* value (in current EU) that is actually applied currently to the module's transducers. **NOTE: all parameters are separated by a *space*.**
Response	"**pppp.pppp [pppp.pppp]...**" The actual *measured pressure values* (in current EU) from each affected channel of the module (highest numbered specified channel first, lowest numbered specified channel last, as per the *pppp* bit map parameter of the *Configure & Start* ('00') sub-command. The *decimal* response datum format (format 0) is always used.

Description: This sub-command (to be executed two or more times) carries out the *data collection phase* of the **Multi-Point Calibration** function for exactly *one* (1) calibration point (i.e., per parameter *pnt*). Each execution applies a specified pressure value; then collects, averages, and stores the data for that calibration point. It must be repeated until all pressure points, as specified by the *npts* parameter of the original *Configure & Start* ('00') sub-command, are applied and their data collected. For each particular point, enter the sub-command after that point's *pressure value* has been properly applied to the module, and that value is stable (unchanging). Pressure may be applied to either the **Cal** or **Run** ports, as necessary. Use a Model 903x Calibrator or some other suitable precision pressure source to generate the pressure.

It is not necessary to enter the two or more calibration points in strict numerical order (i.e., 1, 2, ... *npts*). Any convenient entry order is allowed, though each point's actual *pressure value* must be correctly stated (with the *pppp.pppp* parameter) when executed. Previously entered points may be reentered if it is necessary to account for hysteresis. However, all the points specified by the *pts* parameter of the *Configure & Start* ('00') sub-command must be supplied before the final *Calculate and Apply* ('02') sub-command can be executed, else an error will result.

Example:

- Supply each of the previously-specified three (3) pressure calibration points to the Multi-Point Calibration function, as was stated in the *previous example* of the *Configure and Start* ('00') sub-command. Assume that all the affected four (4) channels have differential transducers with the same -5 to +5 psi range. Include at least one pressure point in the negative range of these transducers.

  "**C 01 1 -2.5**"
  "**C 01 2 0.0**"
  "**C 01 3 5.0**"

  Read responses (separately after each command executed above):

  "-2.4998 -2.4999 -2.5001 -2.500"
  "0.0 0.0013 -0.0133 -0.00001"
  "5.0091 4.9992 5.0010 4.9998"

  Data are returned in *reverse* channel number order (i.e., 4, 3, 2, 1) in each response.

Command 'C'- Sub-command Index 02: Calculate & Apply Correction Coefficients

This sub-command has no additional parameters.

Command	"**C 02**" 'C' is the *command* letter. ' 02' is the *sub-command index* (*ii*) for *Calculate & Apply* **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter — returned if the required number of calibration data points had their data successfully collected previously, and the resulting calculated data is reasonable. Else, an error ('N') response is returned.

Description: This sub-command finishes the **Multi-Point Calibration** function, previously started by the *Configure & Start* ('00') sub-command. It calculates new correction coefficients using the pressure data collected by all required executions of the *Collect Data* ('01') sub-command.

All the averaged data points collected previously are checked for reasonableness, and then a new set of *zero* and *gain* correction coefficients are calculated by the *least-squares* method for each channel (transducer) affected by the calibration. These are stored in the module's volatile memory for use by all subsequent EU data conversion of these channels until the module is *reset* or *powered off*. These coefficients may be stored in the non-volatile memory of the module's transducers with the **'w'** command (see indexes 08 and 09 for that command). The latest calculated *zero* and *gain* coefficients may be inspected with the **'u'** command at any time for any channel.

Finally, this sub-command restores the original "A/D samples for averaging" count used by the module's data acquisition process to the value that was in use before the **Multi-Point Calibration** function was originally started.

Example:

- Finish the **Multi-Point Calibration** function previously started (as indicated by the *previous examples* of **'C'** sub-commands '00' and '01'). Calculate new adjustment coefficients, and save them in the non-volatile memory of the module's transducers. These new coefficients will then be used for all subsequently calculated EU data acquired by the module, until another calibration function is performed in the future.

  "**C 02**"
  "**w08**"
  "**w09**"

  Read responses (separately for each command executed above):
  "A"
  "A"
  "A"

  If an error ("N") response is returned on the first command, either the correct number of calibration points (per '00' sub-command) were not supplied with reasonable pressure data values (via the multiple '01' sub-commands), or the collected data yielded new calculated coefficients with unreasonable values.

  If execution of the last two **'w'** commands is skipped above, the new calibration data obtained will be stored only in volatile storage, and will be available for use only until the module is RESET or loses power.

Command 'C'— Sub-command Index 03: Abort Multi-Point Calibration

This sub-command has no additional parameters.

Command	"**C 03**" 'C' is the *command* letter. ' 03' is the *sub-command index* (*ii*) for *Abort*. **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter

Description: Aborts the **Multi-Point Calibration** function, if it is currently in progress. This sub-command also restores the original "A/D samples for averaging" count to the module that was in use before the calibration function was started.

It should be noted that executing the *Configure & Start* ('00') sub-command again, after the calibration function has started collecting data (per *Collect Data* ('01') sub-commands), but before the final data are calculated (per *Calculate & Apply* ('02') sub-command), will have the same affect as this Abort function.

Example:

- Abort the Multi-Point Calibration function previously started

  "**C 03**"

  Read response:

  "A"

READ TRANSDUCER VOLTAGES (Command 'V')

Purpose: Returns, for the specified channels, the most recently acquired *raw pressure* data, converted to volts directly from the averaged A/D counts. This simple engineering-unit conversion bypasses any usage of the transducer's factory-calculated coefficients or the final calibration process's *correction* coefficients (offset and gain). Each datum returned in the response will be in the specified high-precision data format. **This command is intended for advanced users only and is not required for normal operation.**

Command	"**V[*p*]*ppppf***' 'V' is the *command* letter '[*p*]*pppp*' is the *position* field '*f*' is the *format* field
Response	" ***dddd*[*dddd*]...**" ' *dddd*' are *datum* fields, each with a leading *space* (except *f* =7).

Description: The 4 or 5 character hex *position* field ([*p*]*pppp*) specifies a 16 or 20 bit binary bit-map, with each bit set to 1 to specify a particular channel number (S & P external rack channels, plus internal channels 16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *datum* (' *dddd*') that will be returned in the requested response. The first datum returned in the response will be for the highest channel number requested. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	**converts each internal response *datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Example:

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal voltage data for internal channels 1, 5, 9, and 13:

  "**V11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  " **4.999999 -4.989500 0.005390 2.500001**"

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal voltage data for external S & P channels only:

  "**V300000**"

  Response contains data for channels S then P (left to right):

  " 0.005880 1.500003"

CALCULATE AND SET GAINS (Command 'Z')

Purpose: Instructs a module to calculate new *gain* coefficients, with either *full-scale* pressure (or a *specified* pressure) applied to the specified internal channels. These new coefficients update part of the module's internal calibration coefficient database, used to convert any subsequent raw data (from any of the specified channels) into engineering units data. The new gain values are also returned in the response. This command is sometimes called a Gain calibration.

Command	"**Z*pppp*[*vv.vvvv*]" 'Z' is the *command* letter '*pppp*' is the *position* field ' *vv.vvvv*' is an [optional] *pressure* value, preceded by a *space* character.
Response	" ***g.gggg*[*g.gggg*]...**" '*g.gggg*' are the actual *gain* data values returned, each preceded by a *space*.

Description: The position field may have 0 or 4 characters. If no position field is specified, *gain* coefficients for all internal module channels (16-1) will be calculated and returned. If a position field is specified, *gain* coefficients for only the channels whose bits are set (=1) will be calculated and returned. If the optional *pressure* value [*vv.vvvv*] is specified, the *position* field must be 4 characters, even when all channels are to be specified. Gain values are returned in the response in order of *highest specified channel* to *lowest specified channel*, with data formatted per an *implied* decimal format (*f*=0).

NOTE: *This command may only be applied to the sixteen (16) internal channels. It is not applicable for the external 98RK-1's purge/supply (P & S) channels.*

Normally this command requires that the *exact full scale* input pressure be applied to the affected channels. The optional *pressure* value [vv.vvvv] allows the user to specify *any suitable upscale pressure* in the *current engineering units*. For best results, pressures in excess of 90% of full scale should be applied. A leading *space* character must precede the *pressure value* parameter. The desired calibrating pressure must be applied to all of the specified channels (and allowed to stabilize) before this command is executed. Such a pressure is presumably generated by a separate Model 903x calibrator module or suitable user-supplied substitute.

Internal 9816 firmware limits the allowed values for the calculated gain coefficients between **0** and 100. If internal calculations result in gain coefficients outside of this range, a default value of 1.00 will be used.

Notice that unlike the *Calculate and Set Offsets* ('h') command, this command does not automatically move the module's calibration valve to its CAL position. A command to do this must precede this command. The reader is referred to **Chapter 4**, **Section 4.3** for additional details concerning the performance of a Span Calibration.

Note

The calculated *gain* values from the latest 'Z' command will be lost when the module is powered OFF. To save these *gain* terms to each transducer's nonvolatile memory, refer to the *Set Operating Options* ('w') command (index 09).

Example:

- Send TCP/IP command to a 9816 module (via its open socket) to calculate and set gain coefficients for channels 8 through 4. Instruct the module to use 14.8890 psi as the applied pressure instead of each transducer's full-scale value:

  "**Z00F8 14.8890**"

  Response:

  " 1.01289 1.06953 1.03750 0.99704 1.10051"

  Actual gain values are returned in the above response as decimal ASCII strings, each preceded by a *space* character. From left-to-right: they are for channels 8, 7, 6, 5, and 4.

READ TRANSDUCER A/D COUNTS (Command 'a')

Purpose: Returns the most recently acquired *raw pressure* data for the specified channels in averaged signed A/D counts (in the range -32768 to +32767). This simple data bypasses any usage of the transducer's factory-calculated coefficients or the final calibration process's correction coefficients (offset and gain). Each datum returned in the response will be in the specified high-precision data format, but representing A/D counts as a signed integer average. (The formula for converting A/D Counts to volts is: *Volts = A/D Counts * 5/32768*.) **This command is intended for advanced users only and is not required for normal operation.**

Command	"**a[*p*]*ppppf***" 'a' is the *command* letter ' [*p*]*pppp*' is the *position* field '*f*' is the *format* field
Response	" ***dddd*[*dddd*]...**" ' *dddd*' are *datum* fields, each with a leading *space* (except *f* =7).

Description: The 4 or 5 character hex *position* field ([*p*]*pppp*) specifies a 16 or 20 bit binary bit-map, with each bit set to 1 to specify a particular channel number (S & P external rack channels, plus internal channels 16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *data* field (*dddd*) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number requested. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	**converts each internal response *datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Example:

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal raw "pressure" A/D counts data for internal channels 1, 5, 9, and 13:

  "**a11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  "32767.000000 -32700.000000 10.000000 16385.000000"

  Please note that channel 13 is saturated at +full scale and channel 9 is almost saturated at -full scale. Channel 5 reads near zero and channel 1 is about ½ +full-scale.

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal raw "pressure" A/D counts data for the external P & S channels only:

  "**a300000**"

  Response contains data for channels P then S (left to right):

  "-10.000000 2.000000"

  Note that both values are near zero counts (+ or -).

READ HIGH-SPEED DATA (Command 'b')

Purpose: Returns the most recent scanned and averaged data from *all channels* of the module as fast as possible. Data is returned directly in its internal (IEEE single-precision float) binary form (as per *implied* format 7). It is used as a *faster alternative* to the ***Read High-Precision Data*** (**'r'**) command, since **'b'** does not have to parse the position or format parameters, nor does it have to transform or encode the internal data into any other format when the response is generated.

Command	"**b**" 'b' is the *command* letter
Response	***aaaabbbbcccc..rrrr*** each 4-byte *datum* (e.g, '*aaaa*') is a non-human readable 32-bit (4-byte) big-endian binary value (format 7) representing an IEEE single-precision internal float value.

Description: Returns data for all of the module's external plus internal channels, in order highest channel number to lowest channel number. Thus, the purge (P) rack channel reading will always be the first 4-byte (32-bit binary, big-endian, IEEE floating-point) value ('*aaaa*') sent in the response. It is followed by similar values (*'bbbb', 'cccc', ... 'rrrr'*) for the source air (S) rack channel, and then internal channels 16-1. Unless the EU conversion scalar is altered, the returned data will be in units of psi.

Example:

- Send TCP/IP command to a Model 9816 module (via its "socket" connection) to return data as fast possible:

  "**b**"

  Data from the most recent scan of all the module's channels are returned in pure binary form, 4-bytes per channel (big endian):

  aaaabbbbcccc .. rrrrpppp

  Note that this response is not shown within quotes " " since it is not a valid ASCII character string.

DEFINE/CONTROL AUTONOMOUS HOST STREAMS (Command 'c')

Purpose: Defines and controls the autonomous delivery of any of up to three concurrent high-speed data streams to the host computer. Such data streams may be delivered "continuously" without bound (until a command explicitly stops them), or be delivered in a "limited" amount (until a pre-specified fixed number of data packets have been sent). Each packet delivered may be synchronized by a "hardware trigger" or each packet may be delivered periodically as controlled by an internal software clock. These concurrent host streams are an alternate method of acquiring/delivering data rather than using the **Read High-Precision Data** (**'r'**) command or the **Read High-Speed Data** (**'b'**) command.

Host data streams, once activated in a module, deliver a sequence of TCP/IP data packets autonomously to the host (i.e., without host sending any particular command to the module to request each packet). **WARNING:** If these data streams are defined to occur at high rates, then each data packet received by the host must be processed and disposed of in a timely manner.

Various *sub-commands* (described on the following pages) are used to identify the various definition and control options of the following general **'c'** command.

Command	"**c *ii*[*dddd*]...** " 'c' is the *command* letter. ' *ii*' is a *sub-command* index (augment code) preceded by a *space* character. ' *dddd*' are one or more optional *datum* fields, each preceded by a *space* character, which are parameters that differ per augment code *ii.* **NOTE: all parameters are separated by a *space*.**
Response	Depends upon particular sub-command (*ii*) sent. See below.
Autonomous Packet	Depends upon particular sub-command (*ii*) sent. See below.

Description: The firmware of a Model 9816 module, once fully initialized, continuously scans and converts data for all internal pressure channels at the highest possible speed. The result of such scanning is a continuously-updated *EU data buffer,* available to three concurrent host data delivery tasks, or available to other standard data acquisition commands of the module. Each host delivery task can grab engineering-unit data values from the *EU data buffer* and deliver them to the host in its own programmable data stream (a sequence of TCP/IP packets that autonomously arrive in the host, as long as the host has enough TCP/IP buffering space to hold them).

Special augments of this command (using the first parameter, *ii*) can configure each data stream with the particular channels whose data are delivered, the datum format, the delivery rate, and other characteristics. It can also start, stop, or un-define a single stream or all defined streams.

The maximum rate of any one stream's delivery is practically limited to the maximum possible scan and data conversion rate of all the module's channels. Normally, these programmable host streams deliver host data at rates equal to or slower than this natural cycle. For a typical application, the first stream delivers a few channels, at a high rate (as defined by a hardware trigger). The second stream delivers other channels at a medium rate (some multiple of the trigger period), and the third stream can deliver still other channels at a slower rate (also a multiple of the trigger period).

Note

Avoid confusing this Configure/Control Autonomous Host Streams command 'c' (lower case c) with the Configure/Control Multi-Point Calibration command 'C' (upper case C). Like 'C', but unlike most other module commands, all sub-commands of this command require a *space* between the *command id* ('c') and the first parameter (*ii*).

Command 'c'— Sub-command Index 00: Configure a Host Delivery Stream

This sub-command is used to configure the parameters of each of the three possible concurrent host delivery streams, one at a time. Following this configuration phase, the stream (1, 2, or 3) may be started and stopped with other sub-commands. The sub-command's format is:

Command	"**c 00 *st* [[[[*p*]*p*]*p*]*p*]*p sync per f num***" 'c' is the *command* letter. ' 00' is the *sub-command index* (*ii*) for configuration. ' *st*' is the *stream id* digit (1, 2, or 3). ' *ppppp*' is a 1-5 digit hex *position* field (channel selection bit map), capable of selecting 1-18 external/internal channels. ' *sync*' is *sync type* (0=hardware trigger or 1=clock). ' *per*' is the *period* (if *sync*=0: # of trigger periods or if *sync*=1: delay timer period in msec). ' *f*' is the *format* of each *acquired* datum in stream. ' *num*' is the *number of packets delivered* in stream (0=unlimited/continuous). **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter
Autonomous Packet	none generated

Description: Configures a particular stream ('***st***') to deliver data packets autonomously to the Configures a particular *stream* (*st*) to deliver data packets autonomously to the host, with each packet containing *selected acquired data* for the channels specified. These channels are specified by a bit map (4-20-bits) encoded as a 1-5 hex digit *position* field (*ppppp* as described in Section 3.1.3.3). A separate sub-command (*ii*=05) may be used to *select* which *acquired data* are included in each stream. By default, only Pressure EU Data are selected (if ii=05 sub-command never executed for stream).

The individual data packets of the stream may be synchronized with either an external (user-supplied) hardware trigger or a periodic clock interrupt generated inside each module. This choice is made with the *sync type (sync)* parameter (a single digit) where: 0 = synchronize with hardware trigger; 1= synchronize with periodic software clock.

When the hardware **trigger** is used to synchronize **data output** (*sync* = 0), it is assumed that the user would prefer to also synchronize the internal data *acquisition* cycle. For this reason, when a stream utilizing hardware trigger is started, the module firmware switches out of the free-running continuous data acquisition mode described earlier. Instead, the **Model 9816** waits in an idle mode until a hardware trigger is received to initiate a host stream output. Only on the receipt of that hardware trigger will the module scan and EU convert all

internal channels. Following completion of the acquisition (and EU conversion) cycle, the module will also deliver the requested data channels to the host. In this manner, users are provided with highly synchronized data acquisition *and* delivery from one or more modules. If a module waits in the idle mode for an extended period of time without receiving a data request, it will periodically initiate its own internal data acquisition cycles so as to update internal thermal coefficients. When all hardware triggered streams are complete or aborted, an individual module will return to the default mode of continuous scanning and EU conversion.

When the **internal software timer** is used to control host stream output rates (*sync*=1), note that the internal clock frequency variances will result in slightly different timing between modules. Although these differences in timing are slight, they may result in noticeable differences in output timing between modules over a long period of time. If highly synchronized data output is required from multiple modules, the hardware trigger mode should be used.

The *period (per)* parameter is a positive decimal integer count (from 0 to 2147483647, specified with 1 to 10 numeric characters as needed). Its meaning (described in the following table) depends on the *sync type (sync)* parameter described above.

sync	meaning of ***per***
0	number of hardware trigger periods to wait before sending each packet
1	delay period (in milliseconds) to wait between sending each packet **NOTE:** minimum is 10 milliseconds

The *f* parameter identifies the *format* of each *selected acquired datum* in each stream packet, and is a single numeric digit. Valid format codes are listed in the following table:

f	**converts each internal *selected acquired datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Unless the EU conversion scalar is altered, returned pressure data will be in units of psi. See command **'v'**, array 11, coefficient 01 for other units.

NOTE: With the exception of binary format 7, all other formats include a leading *space* in each datum delivered in each stream packet.

The *number of stream packets* (*num*) parameter is a positive integer count (specified with 1 to 5 numeric digits as needed). It sets a finite limit on the number of packets delivered in the host data stream. The value 0 for this parameter requests "continuous" output packets for the defined host stream (unbounded).

Example:

- Configure three (3) separate autonomous host delivery streams, and divide the module's channels between them. Channels (1-4) must be delivered to host at a 10 Hz rate, channels 5-8 may be delivered at half that rate, while the remaining channels 9-16 are delivered at half the previous rate. All streams are generated continuously and synchronized with the internal clock at 100 msec., 200 msec., and 400 msec. periods, respectively. Data are requested in single precision binary IEEE float format (*f* = 7).

  "**c 00 1 000F 1 100 7 0**"
  "**c 00 2 00F0 1 200 7 0**"
  "**c 00 3 FF00 1 400 7 0**"

  Read responses:

  "**A**"
  "**A**"
  "**A**"

  To similarly acquire data at "relative" rates (1, 2, and 4) using a periodic *hardware* trigger (assumed to also cycle at 10 Hz rate), enter the commands:

  "**c 00 1 000F 0 1 7 0**"
  "**c 00 2 00F0 0 2 7 0**"
  "**c 00 3 FF00 0 4 7 0**"

  Read responses:

  "A"
  "A"
  "A"

Command 'c'— Sub-command Index 01: Start Stream

This sub-command is used to start the delivery of any previously configured host stream in a module. If the stream started is of "continuous" duration, then it will be necessary to use the Stop Stream sub-command later. Otherwise, the stream will end automatically if a finite number of packets has been specified for it. This sub-command may also be used to resume a previously stopped host stream that has not transmitted all requested data packets. The sub-command's format is:

Command	"**c 01 *st***" 'c' is the *command* letter. ' 01' is the sub-command index (*ii*) for ***Start Stream***. ' *st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*). **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter
Autonomous Packet	"*tssss*[*dddd*[*dddd*]*...*" '*t*' is a 1-byte binary (8-bit) value identifying the *stream* number (1-3). '*ssss*' is a 4-byte binary integer (32-bit, big endian) *packet sequence number*. ' *dddd*' are the *selected acquired datum* values in the selected format, plus a leading *space* (except *f*=7).

Description: This sub-command starts a particular specified host stream (*st*=1-3); or starts *all* configured host streams with a single command (*st*=0). Each autonomous host stream packet begins with a 5-byte fixed-format (binary) data header (*tssss*). The first byte (*t*) identifies the host stream, while a 32-bit unsigned binary sequence number (*ssss*) completes the header. This sequence number will start at one (1) for the first packet returned by a stream and increment for each other returned packet of that stream. In the case of a "continuous" data stream, the sequence number may overflow the maximum permissible 32-bit integer value. If this occurs, the sequence number value will wrap around to zero (0) following the largest 32-bit value (4294967295) and then continue to increment by one for each returned packet. The sequence number field is intended to provide a mechanism for host software to ensure that host data stream packets are processed or stored in the order in which they were obtained by the 9816. Each of the three possible host streams will report their own unique sequence number. Note that if a previously stopped data stream is restarted, the returned sequence numbers will resume with the next number at the point of the stream's termination. The sequence numbers will not restart at one if a scan list is temporarily stopped and then restarted without reconfiguring the stream. A "limited" stream will terminate once this sequence number equals the requested number of packets for the stream.

For periodic hardware-triggered streams, that are never suspended and resumed after being initially enabled, the sequence number may also serve as a "relative" time stamp if the *period* (in milliseconds) of the hardware trigger is known.

If a special sub-command (ii=05) is used to select the content of a stream, other *status* data may immediately follow the binary stream header and *precede* the default Pressure EU Data (if selected). Still other *special* acquired data (per selected channel) may follow the Pressure EU Data. The total of all groups of *selected acquired data* in each packet will be ordered from highest channel number requested to lowest channel number requested. Each such datum (*dddd*) will be output per the format code specified when the stream was configured (by sub-command 00).

Example:

- Start all the streams configured in the previous example:

  "c 01 0"

  Read response:

  "A"

  Soon after the response is received, the requested data stream packets will begin arriving in the host at a quantity, content, and rate determined by each stream's own particular current configuration (per both the 00 and 05 sub-commands).

Command 'c'— Sub-command Index 02: Stop Stream

This sub-command is used to abort (or temporarily suspend) the delivery of any previously started host stream in a module, one at a time or all together, whether the stream was "continuous" or "limited" duration. The sub-command's format is:

Command	"**c 02 *st***" 'c' is the *command* letter. ' 02' is the sub-command index (*ii*) for ***Stop Stream***. ' *st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*). **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter
Autonomous Packet	command stops generation of autonomous packets from the requested stream(s).

Description: This sub-command *stops* the current "run" of a particular specified host stream (*st*=1-3); or *stops* the current "run" of "*all configured*" host streams with a single command (*st*=0).

The *stopped* stream may be *resumed* for any new "runs" with the **Start Stream** sub-command, as long as that stream remains defined in the module. The **Clear Stream** sub-command may be used to un-define a stream. Any stream must first be *reconfigured* with the **Configure A Host Delivery Stream** sub-command (00) to be fully *restartable* with the **Start Stream** sub-command (i.e., to start again with sequence number = 1 for run's first packet).

Example:

- Stop all the streams configured in the previous example:

  "**c 02 0**"

  Read response:

  "A"

Command 'c'— Sub-command Index 03: Clear Stream

This sub-command is used to "undefine" any previously configured host stream in a module, one at a time, or all together. The sub-command's format is:

Command	"**c 03 *st***" 'c' is the *command* letter. ' 03' is the *sub-command* index (*ii*) for **Clear Stream**. ' *st*' is the *stream id* digit (1, 2, or 3, or 0=*all streams*). **NOTE: all parameters are separated by a *space*.**
Response	"**A**" 'A' is the *acknowledge* letter.
Autonomous Packet	none generated

Description: This sub-command *clears* (un-defines) the particular specified host stream (*st*=1-3); or un-defines "all configured" host streams with a single command (*st*=0). Once cleared, a stream must be reconfigured before it can be started.

Example:

- Stop all the streams configured above. Then clear (undefine) only stream 3 and then resume the remaining defined streams 1 and 2:

  "**c 02 0**"
  "**c 03 3**"
  "**c 01 0**"

  Read response:
  "A"

Command 'c' — Sub-command Index 04: Return Stream Information

This sub-command returns current stream configuration information in its response:

Command	**"c 04 *st*"** 'c' is the *command* letter. ' 04' is the *sub-command index* (*ii*) for ***Return Info***. ' *st*' is the *stream id* digit (1, 2, or 3, =0 no allowed). **NOTE: all parameters are separated by a *space*.**
Response	**"*st* [[[[*p*]*p*]*p*]*p*]*p sync per f num*"** '*st*' is the *stream identifier* digit (1, 2, or 3). ' *ppppp*' is a 1-5 hex digit *position* field (channel selection bit map). ' *sync*' is *sync type* character (0 or 1). ' *per*' is the *period* (# trigger periods or delay timer period). ' *f*' is the *format* of the data delivered in stream. ' *num*' is the *number of packets delivered* in the stream. **NOTE: all datum fields are separated by a *space*.**
Autonomous Packet	none generated

Description: This sub-command returns current configuration information for a particular stream. Returned values are defined the same as the sub-command parameters of Configure *a Host Delivery Stream* (sub-command 00). Note that the '*num*' field represents the *number of packets returned so far* (= last sequence number returned, or =0 if stream not yet started).

Example:

- Return scan list information for stream l

  "c 04 1"

  Read response:

  "1 FFFF 0 20 7 32000"

Command 'c' — Sub-command Index 05: Select Data in a Stream

This sub-command sets options that cause a specified stream to deliver specific kinds of information to host. By default, only Pressure EU Data are delivered.

Command	"**c 05 *st bbbb***" 'c' is the *command* letter. ' 05' is the *sub-command index* (*ii*) for ***Select Data***. ' *st*' is the *stream id* digit (1, 2, or 3, =0 no allowed). ' *bbbb*' is the hex option field (bit map*)* to select which options will be returned in the data stream. (See table) **NOTE: all parameters are separated by a *space*.**
Response	**"A"** 'A' is the acknowledge letter.

Description: If this sub-command is never executed for a particular stream, then just **Pressure EU Data** are delivered (by default) in that stream following the fixed format binary header. However, this sub-command may also *delete* these default pressure readings from a stream (by **not** specifying them) — as well as *add other* selected acquired data to a stream (by specifying them).

The *bit map values* (shown in the following table) may be added together to specify *all* the actual data groups that will be delivered in each packet of the specified stream. The first two table entries, if their "bits" are specified, will cause two-byte binary (16-bit, big endian) *status* values to be delivered in the stream packet (immediately following the stream header). The third table entry, if specified, will cause the **Pressure EU Data** to be delivered (next), per the specified format (*f*), and for just the channels specified (P&S, then 16-1), in the configured stream. The remaining table entries (*) will cause other *special* data groups (i.e., raw pressures and EU temperature values, also in A/D counts or voltage forms) to also be delivered in each stream packet. Each of these *special* data groups is also output, if its "bit" is specified, in the order of its table entry (within the packet). Each group will also have a datum per the specified channels, and be in the specified format (per *f*).

Note **Selecting too many other data groups will compromise module performance.**

bbbb (hex)	data selected for inclusion in each stream packet
0001	Enable **Valve Position Status** (see next table)
0002	Enable **DH Temperature Status** (see bit map below)
0010	Enable **Pressure EU Data** (default if never executed)
0020	Enable **Pressure A/D Counts***
0040	Enable **Pressure Voltages***
0080	Enable **DH Temperature EU Data (degrees C)***
0100	Enable **DH Temperature A/D Counts***
0200	Enable **DH Temperature Voltages***

Any **Valve Position Status** datum is delivered as a two-byte binary integer (16-bit, big endian) with the following possible values (shown in hex below). If selected, this datum will follow the stream header in each packet:

status (hex)	Valve Position Status
0000	Valves in **RUN** position
0001	Valves in **CAL** position
0010	Valves in **LEAK/CHARGE** position
0011	Valves in **PURGE** position

Any **DH Temperature Status** datum is delivered as a two-byte binary bit map (16-bit, big endian) with each bit representing the status of DH #16 through DH #1 respectively. A bit value of 0 (zero) indicates the DH is operating within its specified limits. A value of 1 (one) indicates the DH is outside its specified limits.

Bit #	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Chan #	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	**1**
Binary	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hex	8				0				0				1			

The above example indicates that Channels 1 and 16 are operating outside the specified temperature limits. This binary datum, when selected, follows the previous Valve Position status datum (or the stream packet header).

Example:

- Configure stream l to return both status fields, and all Pressure EU data

  "c 05 1 0013"

  Read response:

  "A"

  If or when stream 1 is subsequently enabled, data groups in that stream with the *lowest-bit-numbers (table positions)* selected are delivered first. In this example (*bbbb* = 0013), the **Valve Position Status** datum would be first, **DH Temperature Status** datum would be second, and then all the specified **Pressure EU** data would follow last (highest specified channel to lowest specified channel). Of course, the standard 5-byte binary prefix (*tssss*) that begins all stream packets would precede all these data groups (see the Autonomous Packet box in **Start Stream** sub-command (index 01).

Command 'c' — Sub-command Index 06: Select Protocol for Stream Delivery

Command	"**c 06 *st* *pro* [*remport* [*ipaddr*]]**" 'c' is the *command* letter. ' 06' is the *sub-command index* (*ii*) for **Select Protocol**. ' *st*' is the *stream* id digit (0=the ONLY acceptable entry). ' *pro*' is the *protocol* id digit (1=UDP/IP, 0=TCP/IP) ' *remport*' is an optional *remote port number* to which each UDP stream is directed in the host (port 9000 is the default if unspecified). It is ignored if *pro*=0. ' *ipaddr*' is an optional host *IP address* to which each UDP stream is directed (default is the host IP address per current TCP connection that sent this command). It is ignored if *pro*=0. **NOTE: all parameters separated by a *space*.**
Response	**"A"** 'A' is the acknowledge letter.

Description: This command sets the protocol by which every configured autonomous stream is delivered to the host. It must be executed after streams are configured, but before they are enabled.

By default, streams are delivered via the same TCP/IP protocol used to receive commands from host (i.e., via the existing TCP/IP connection used to send this command). However, for special circumstances, all autonomous streams may be delivered to the host via the UDP/IP protocol instead. This command is required only when UDP/IP is to be used. It also can restore the default protocol (to TCP/IP) once it has been changed. The TCP/IP version of the command ignores the optional (*pro* and *ipaddr*) parameters, which have meaning only to the UDP/IP protocol.

Though the command has a *stream* parameter, it is currently limited to changing the protocol of *all defined streams* at the same time (i.e., parameter *st* **must** be = 0, meaning *all configured* streams).

The optional *remport* parameter may be any value in the range 1024 to 65535. However, *remport* = 7001 should be avoided, since NetScanner modules emit *UDP Query* responses to that port, and most host programs should have a UDP socket already bound to that port for receiving these special responses. The choice of *remport* parameter will affect the way host software must handle multiple modules sending streams. If every module uses the same port, then a single host socket can be bound to that port to receive all responses from all modules. The remote IP Address, given to that socket, at time of receipt of the stream's datagram, will identify the particular module who sent the datagram.

Alternately, every module may be given a unique *remport* number, requiring that a host program bind a unique UDP socket to each of these unique *remport* numbers. Then, when a particular socket receives a UDP datagram to its unique port, the module sending it is automatically identified.

The optional *ipaddr* parameter is normally unspecified, causing it to default to use the IP address of the current TCP/IP connection. That way the host need not have to be aware of its own IP address. This parameter is provided in case a special host has multiple network interfaces and wants to use more than one. When used, *ipaddr* requires four dotted numeric fields (*d.d.d.d*). Each *d* is a 1-3 digit decimal number in the range 0-255. The *ipaddr* = 255.255.255.255 is best avoided, unless the UDP datagrams of streams are to be broadcast to all network nodes.

The '***f***' parameter identifies the *format* of each selected acquired datum in each stream packet, and is a single numeric digit. Valid format codes are listed in the following table:

f	**converts each internal *selected acquired datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Example:

- Configure all streams to be delivered via UDP/IP protocol. Host expects the UDP datagrams to arrive via port 7500. The IP Address of the current TCP/IP connection is also used to send each UDP datagram.

  "c 06 0 1 7500"

  Read response:

  "A"

- Configure all streams to be delivered via the default TCP/IP protocol.

  "c 06 0 0"

  Read response:

  "A"

CALCULATE AND SET OFFSETS (Command 'h')

Purpose: Instructs a module to calculate new *offset* coefficients, with zero differential pressure (or a *specified* "generated" pressure) applied to the specified internal channels. These new coefficients update part of the module's internal calibration coefficient database, used to convert any subsequent raw data into engineering units data. The new *offset* values are also returned in the response. This command is sometimes called a *Re-zero* calibration.

Command	"**h*pppp*[*vv.vvvv*]" 'h' is the *command* letter '*pppp*' is the *position* field ' *vv.vvvv*' is an [optional] *pressure value* preceded by a *space* character.
Response	" ***g.gggg*[*g.gggg*]...**" ' *g.gggg*' are the actual *offset* data values returned, each preceded by *a space.*

Description: The position field may have 0 or 4 characters. If no *position* field is specified, *offset* coefficients for *all* internal module channels (16-1) will be calculated and returned. If a *position* field is specified, *offset* coefficients for only the channels whose bits are set (=1) will be calculated and returned. If the optional pressure value [vv.vvvv] is specified (rarely used), the position field must be 4 characters, even when all channels are to be specified. Offset values are returned in the response in order of *highest specified channel* to *lowest specified channel*, with data formatted per an *implied* decimal format (*f*=0).

NOTE: *This command may only be applied to the sixteen (16) internal channels. It is not applicable for the external 98RK-1's purge/supply (P & S) channels.*

Before acquiring data with this command, any addressed Model 9816 module will *normally* attempt to place the calibration valve in the CAL position, so that a zero differential pressure can be applied to all channels via the module's CAL and CAL Ref input port. Simply leaving these ports unattached will allow the transducers to read the appropriate zero differential pressure if ambient air pressure is stable. After data are acquired, the calibration valve will be placed in the RUN position. To disable the automatic shifting of the calibration valve, refer to the ***Set Operating Options*** (**'w'**) command (index 0B). The reader is also referred to **Section 4.2** of **Chapter 4** for additional details concerning the performance of a Re-zero Calibration.

Note **The calculated *offset* values from the latest 'h' command will be lost when the module is powered off. To save these *offset* terms to each transducer's nonvolatile memory refer to the *Set Operating Options* ('w') command (index 08).**

Example:

- Send TCP/IP command to a Model 9816 module (via its open socket) to calculate and set new offset coefficients for channels 16 through 13.

  "**hF000**"

  Response:

  " 0.0010 0.0020 0.0015 0.0025"

  Actual offset values are returned in the above response as decimal ASCII strings, each preceded by a space character. From left-to-right: they are for channels 16, 15, 14, and 13.

READ TEMPERATURE COUNTS (Command 'm')

Purpose: Returns the most recently acquired *raw temperature* data for the specified channels in averaged A/D counts (in the range -32768 to +32767). This command is similar to command **'a'**, except that the raw data reflects a channel's *temperature* signal instead of its *pressur*e signal. Each datum returned in the response will be in the specified high-precision data format, but representing A/D counts as a signed integer average. **This command is intended for advanced users only and is not required for normal operation.**

Command	"**m[*p*]*ppppf***' 'm' is the *command* letter '[*p*]*pppp*' is the *position* field '*f*' is the *format* field
Response	" ***dddd*[*dddd*]...**" ' *dddd*' are *datum* fields, each with a leading *space* (except *f* =7).

Description: The 4 or 5 character hex *position* field ([*p*]*pppp*) specifies a 16 or 20 bit binary bit-map, with each bit set to 1 to specify a particular channel number (S & P external rack channels, plus internal channels 16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *data* field (*dddd*) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number supplied. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	**converts each internal response *datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Example:

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal raw "temperature" A/D counts data for channels 1, 5, 9, and 13:

  "**m11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  " 32767.000000 -32700.000000 10.000000 16385.000000"

  Please note that channel 13 is saturated at +full scale, channel 9 is almost saturated at – full scale. Channel 5 reads near zero, and Channel 1 is about ½ +full-scale.

READ TEMPERATURE VOLTAGES (Command 'n')

Purpose: Returns the most recently acquired *raw temperature* data for the specified channels converted to engineering-unit Volts directly from the averaged A/D counts. It is similar to command **'V'**, except that the raw data reflects a channel's *temperature* signal instead of its *pressur*e signals. Each datum returned in the response will be in the specified high-precision data format. **This command is intended for advanced users only and is not required for normal operation.**

Command	"**n[*p*]*ppppf***' 'n' is the *command* letter '[*p*]*pppp*' is the *position* field '*f*' is the *format* field
Response	" ***dddd*[*dddd*]...**" ' *dddd*' are *datum* fields, each with a leading *space* (except *f* =7).

Description: The 4 or 5 character hex *position* field ([*p*]*pppp*) specifies a 16 or 20 bit binary bit-map, with each bit set to 1 to specify a particular channel number (S & P external rack channels, plus internal channels 16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *datum* field (dddd) that will be returned in the requested response. The first datum returned in the response will be for the highest channel number. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	**converts each internal response *datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Example:

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal Voltage data (of the raw *temperature* signal) for channels 1, 5, 9, and 13:

  "**n11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  "0.53013 0.541698 0.503633 0.000000"

  In this example channels 13, 9, and 5 return normal temperature voltage signals in the range of 0.5 to 0.6 volts. Note that channel 1 returns a value of 0.0 volts, indicating a possible error in its temperature signal.

READ MODULE STATUS (Command 'q')

Purpose: Returns requested module status information.

Command	"**q*ii***" 'q' is the *command* letter. '*ii*' is the *status index* field.
Response	"***hhhh***" '*hhhh*' is a 4-digit hex *datum* (or other (**) decimal *datum)*.

Description: The 2-digit hex *index* field (*ii*) chooses a particular status field to be returned. Returned value is described in following table for each index (a third column shows *any* **'w'** command index for ***setting*** same option):

ii	**returned value 4-digit hex or other decimal (**)**	**'w'** set index
00	**Module's Model Number**, as decimal (**) integer value (e.g., 9816).	
01	**Firmware Version**, as hex value (expressed internally as integer *version* * 100). (e.g. hex '0100' = 256 decimal, means Version 2.56)	
02	**Power-up Status**, as 16-bit hex bit map, bits having the following meaning:	
	Bit 0 (LSB): A/D Failure Error.	
	Bit 1: Transducer Re-zero Adjustment (offset) Term Range Error (out-of-range values set to 0.0 internally).	
	Bit 2: Transducer Span Adjustment (gain) Term Range Error (out-of-range values set to 1.0 internally).	
	Bit 3: Temperature Correction Coefficients Not Present or Out-of-Range (if transducer has one or more bad coefficients, all set to 0.0).	
	Bit 4: reserved (for transducer checksum)	
	Bit 5: FLASH Initialized Data Section Checksum Error (if error, all data variables set to factory defaults and stored in FLASH).	
	Bit 6: SRAM Error.	
	Bit 7: Error Reading External DHs.	
03	reserved	
04	reserved	
05	**Number of A/D Samples To Average**, as hex value (e.g., 000A=10 decimal).	10

06	**IP Address Resolution Method**, as hex state: 0000 = **Use Static IP Address** stored in module's non-volatile memory 0001 = **Get Dynamic IP Address** from external RARP/BOOTP server	13
07	**TCP Back-Off Delay**, as hex *value* (or FFFF). FFFF means use low-order byte of module's Ethernet Address as *value* instead. In either case, *back-off delay* in *microseconds* is calculated from *decimal* equivalent of hex *value*: delay = *decvalue* * 20	14
08	**TCP/IP Data Field Size Prefix** (with 2-byte big-endian binary value), as hex state: 0000 = None (default) 0001 = Yes	16
09	**TCP Connect Port**, as hex value (e.g. 2328 = 9000 *decimal*, default).	17
0A	**Auto UDP Broadcast@Reset**, as hex state: 0000 = No (default) 0001 = Yes	18
0B	**Position of 4-state Internal Calibration Valves** (C1/C2, C3/C4), as hex state: 0000 = RUN position (C2/C4 Energized, C1/C3 Not) 0001 = CAL/RE-ZERO position (C1/C4 Energized, C2/C3 Not) 0010 = LEAK/CHARGE position (C2/C3 Energized, C1/C4 Not) 0011 = PURGE position (C1/C3 Energized, C2/C4 Not) (see end-of-table NOTE +) (see also Chart at end of **'w'** command)	12/0C 00/00 00/01 01/00 01/01
0C	**Temperature Status of Each Scanner Transducer**, as 16-bit hex bit map, each bit representing the current status of a transducer/channel (16-1)). Bit values are: 0= transducer operating within the specified operational limits. 1= transducer operating outside the specified limits. (see end-of-table NOTE +)	
0D	**Minimum Temperature Alarm Set Point** (in degrees C), as decimal (**) format 0 representation of internal IEEE float, with leading *space*).	19
0E	**Maximum Temperature Alarm Set Point** (in degrees C), as decimal (**) format 0 representation of internal IEEE float, with leading *space*).	19
0F	**Cluster** *(C)*, **Rack** *(R)*, **and Slot** *(S)* **Address**, each item encoded as a hex digit (most significant digit always zero): 0*CRS* (see end-of-table NOTE ++)	
10	**External DH Scan Interval** (in seconds) as decimal (**) integer value.	1A
11	**Thermal Update Scan Interval** (in seconds) as decimal (**) integer value.	1B

(+)NOTE: These 4-byte hex status fields may also be returned in autonomous data streams, but as pure binary extensions of each stream packet's binary header (see **'c'** command, *ii*=05, *bbbb*=0002).

(++)NOTE: The **98RK-1 Scanner Interface Rack** can operate as a single unit with up to eight **Model 9816** pressure scanners installed in slots of each rack. Racks may also be grouped together in *clusters* of racks as part of a larger data acquisition system installation. In order to physically identify individual

scanners within such a larger system, a simple three part addressing scheme is available. Individual scanners are identified by their *Cluster, Rack,* and *Slot* (CRS) address, a three-digit hexadecimal number.

A *cluster* (the most significant address unit), is numbered 0-F (0-15 decimal) for a total of 16 clusters (clusters often refer to other geographical units like *control rooms* or *test stands*).

A *rack* (the middle address digit), is numbered 0-F (0-15 decimal) for a total of 16 racks per cluster. (NOTE: The **98RK-1** front-panel switch for setting the *rack* address is labeled 0-15 decimal instead of hex 0-F)

A *slot* (the least significant address digit), numbered 1 through 8, designates a particular 9816 pressure scanner in a rack.

Example:

- Request model number from any **NetScanner™ System** module:

  "**q00**"

  Read response indicating a Model 9816:

  "9816"

- Request TCP back-off delay for any **NetScanner™ System** module:

  "**q07**"

  Read hex (16-bit binary) response:

  "001F" (31 decimal, or 31*20= 620 µsec.)

READ HIGH-PRECISION DATA (Command 'r')

Purpose: Returns the most recently acquired *engineering-unit* ***pressure*** data for the specified channels. Each datum returned in the response will be in the specified high-precision data format.

Command	"**r[*p*]*ppppf***" 'r' is the *command* letter '[*p*]*pppp*' is the *position* field '*f*' is the *format* field
Response	" ***dddd*[*dddd*]...**" ' *dddd*' are *datum* fields, each with a leading *space* (except *f* =7).

Description: The 4 or 5 character hex *position* field ([*p*]*pppp*) specifies a 16 or 20 bit binary bit-map, with each bit set to 1 to specify a particular channel number (S & P external rack channels, plus internal channels 16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *data* field (*dddd*) that will be returned in the requested response. **The first datum returned in the response will be for the highest channel number specified.** Each datum will be preceded by a space character (except in the case of binary format 7). Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	**converts each internal response *datum* value from**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Unless the EU conversion scalar is altered, the returned data will be in units of psi.

Example:

- Send TCP/IP command to 9816 module (via its connected socket), that returns decimal pressure data for channels 1, 5, 9, and 13 in ASCII fixed point format.

  "**r11110**"

  Response contains data for channels 13, 9, 5, and 1 (left to right):

  "1.234000 0.989500 1.005390 0.899602"

READ TRANSDUCER TEMPERATURE (Command 't')

Purpose: Returns the most recently acquired *engineering-unit* ***temperature*** data (in ºC) for the specified channels. Each datum returned in the response will be in the specified high-precision data format.

Command	"**t[*p*]*ppppf***" 't' is the *command* letter '[*p*]*pppp*' is the *position* field '*f*' is the *format* field
Response	" ***dddd*[*dddd*]...**" ' *dddd*' are *datum* fields, each with a leading *space* (except *f* =7).

Description: The 4 or 5 character hex *position* field ([*p*]*pppp*) specifies a 16 or 20 bit binary bit-map, with each bit set to 1 to specify a particular channel number (S & P external rack channels, plus internal channels 16-1, left-to-right).

The 1-character *format* field (*f*) specifies the format of each *data* field (*dddd*) that will be returned in the requested response. **The first datum returned in the response will be for the highest channel number specified.** Each datum will be preceded by a space character. Some formats may not be applicable to the specific type of data being requested. Valid formats are shown in the following table:

f	**Converts each internal response *datum* value from..**			**max.char.**
0	single binary float	to	7-10-digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex integer " xxxxxxxx"	9
2	double binary float	to	16-digit hex integer " xxxxxxxxxxxxxxxx"	17
5	single binary float	to	long integer (EU*1000) then to 8-digit hex integer	9
7	single binary float	to	single binary float (big endian: msb first)	4
8	single binary float	to	single binary float (little endian: lsb first)	4

Example:

- Send TCP/IP command to 9816 module (via its connected socket) that returns decimal temperature data for channels 1, 5, 9, and 13:

  "**t11110**"

  Response contains data (in to right): channels 13, 9, 5, and 1 (left

  "21.234000 20.989500 21.005390 20.899602"

READ INTERNAL COEFFICIENTS (Command 'u')

Purpose: Returns one (or more contiguous) requested internal coefficient(s) in a specified internal coefficient array, and in the specified response data format.

Command	"**u*faacc*[-*cc*]**" 'u' is the *command* letter. '*f*' is the *format* field. '*aa*' is the *array index* field. '*cc*[-cc]' is *coefficient index* [or contiguous *range*].
Response	***dddd*[*dddd*]...**" ' *dddd*' are the *datum* fields, each with a leading *space*.

Description: The 1-character *format* field (*f*) is a single digit that defines the format of each returned datum in the response. All *datum* (*dddd*) fields returned will be preceded by a *space* character. Most coefficients have a floating point datum type (*f*=0-1), while others have an integer datum type (*f*=5). Requesting an improper format will result in an "N08" error response. Valid format types for coefficients are shown in the following table:

f	**Converts each internal value from..**			**max.char.**
0	single binary float	to	7-10 digit signed decimal " [-xxx]x.xxxxxx"	13
1	single binary float	to	8-digit hex " xxxxxxxx"	9
5	long binary integer	to	8-digit hex " xxxxxxxx"	9

The 2-character *array index* field (*aa*) is a **hexadecimal value** selecting a particular internal coefficient array. The first *array index* (*aa*=01) refers to channel 1's transducer, the 16th (*aa*=10) refers to channel 16's transducer. Finally, the last array (*aa*=11) refers to a special global array.

The 2-character *coefficient index* field (*cc*) is a **hexadecimal value** that selects a particular coefficient within the specified array. Multiple contiguous coefficients may be specified by using a *coefficient index "range"* specified by adding a hyphen (negative sign) between two such indexes (*cc-cc*).

Internal DH200 Transducer Coefficient arrays for internal channels 1-16 are selected with ***array indexes aa*=01 through *aa*=10 (hex).** All valid *coefficient indexes* (for each of these arrays) are listed in the following table:

cc	Transducer Coefficient Description	Datum Type
00	**Re-zero Cal Adjustment** (offset) term	FLOAT
01	**Span Cal Adjustment** (gain) term	FLOAT
02	Dynamic EU Conversion coefficient c0	FLOAT
03	Dynamic EU Conversion coefficient c1	FLOAT
04	Dynamic EU Conversion coefficient c2	FLOAT
05	Dynamic EU Conversion coefficient c3	FLOAT
06	Dynamic EU Conversion coefficient c4	FLOAT
07	**User Defined Date** field (see end-of-table note)	INTEGER
08	**Date of Factory Calibration** (see end-of-table note)	INTEGER
09	Transducer Manufacturing Reference number	INTEGER
0A	Transducer Full-Scale Range code (see Appendix I)	INTEGER
0B	Temperature 1 Pressure 1 voltage	FLOAT
0C	Temperature 1 Pressure 2 voltage	FLOAT
0D	Temperature 1 Pressure 3 voltage	FLOAT
0E	Temperature 1 Pressure 4 voltage	FLOAT
0F	Temperature 1 Pressure 5 voltage	FLOAT
10-14	Temperature 2, Pressures 1-5 voltages	FLOAT
15-19	Temperature 3, Pressures 1-5 voltages	FLOAT
1A-1E	Temperature 4, Pressures 1-5 voltages	FLOAT
1F-23	Temperature 5, Pressures 1-5 voltages	FLOAT
24-28	Temperature 6, Pressures 1-5 voltages	FLOAT
29-2D	reserved for future use (temperature 7)	FLOAT
2E	Temperature 1 Temperature Output voltage at 0 psi	FLOAT
2F	Temperature 2 Temperature Output voltage at 0 psi	FLOAT
30	Temperature 3 Temperature Output voltage at 0 psi	FLOAT
31	Temperature 4 Temperature Output voltage at 0 psi	FLOAT
32	Temperature 5 Temperature Output voltage at 0 psi	FLOAT
33	Temperature 6 Temperature Output voltage at 0 psi	FLOAT

cc	Transducer Coefficient Description	Datum Type
34	(reserved) Temperature 7 Temperature Output voltage at 0 psi	FLOAT
35	Temp Vs Pressure Correction coefficient (t0)	FLOAT
36	Temp Vs Pressure Correction coefficient (t1)	FLOAT
37	Temp Vs Pressure Correction coefficient (t2)	FLOAT
38	Temp Vs Pressure Correction coefficient (t3)	FLOAT

NOTES: The **Date of Factory Calibration** field (*cc* = 08) identifies the date of factory calibration for the DH200 transducer. It is stored internally as a 32-bit integer whose value is in the format of yymmdd (year, month, day).

The **User Defined Date** field (*cc* = 07) is a 32-bit integer which is encoded in a similar manner. Possible uses are to indicate the date of last user zero and/or span calibration or possibly the date of next required calibration. If this optional field is used, the user is responsible for correctly encoding the date into the proper 32-bit integer value. Any modifications of this field (using the ***Download Internal Coefficients*** ('***v***') command) will result in the new value automatically being entered to transducer's nonvolatile memory.

A special single ***Other Coefficients*** array is selected with ***array index aa* = 11 (hex).** All the valid *coefficient indexes* (for this array only) are listed in the following table:

cc	Other Coefficients Description	Datum Type
00	reserved - EU Conversion Offset term	FLOAT
01	**EU Pressure Conversion Scaler** (default = 1.0)	FLOAT
02	reserved - EU Conversion Non-Linearity term	FLOAT
03	Module Reference Voltage value	FLOAT
04	Reserved for factory use	FLOAT
05	Reserved for factory use	FLOAT
06	Reserved for factory use	FLOAT
07	Reserved for factory use	FLOAT
08	9816 External DH Amplifier Zero Offset	FLOAT
09	9816 External DH Amplifier Span Adjustment	FLOAT

Example:

- Send TCP/IP command to 9816 module (via its connected socket) requesting the most recent calibration adjustment's *offset* and *gain* terms (*cc*=00-01), and the adjacent factory-determined transducer coefficients C0 through C4 (*cc*=02-06): for transducer 1: Data requested in ASCII-hex format representing the internal binary floating point format

  "u10100-06"

  Response returned is:

  "3B200A6E . . 00000000"

Note **The maximum response size is 300 characters. If the requested range of coefficients requested exceeds this, the 9816 will return an "N07" error response.**

DOWNLOAD INTERNAL COEFFICIENTS (Command 'v')

Purpose: Downloads one or more internal coefficients to the module.

Command	"**v*faacc*[-*cc*] *dddd*[*dddd*]...**"** 'v' is the *command* letter. '*f*' is the *format* field. '*aa*' is the *array* index field. '*cc*[-*cc*]' is *coefficient* index [or contiguous range]. ' *dddd*' are the *datum* fields, each with a leading *space*.
Response	"**A**" 'A' is the *acknowledge* letter.

Description: The 1-character *format* field (*f*) is a single digit that defines the format of each coefficient to be downloaded in the command's datum (*dddd*) fields, with each datum preceded by a *space* character. Most coefficients have a floating point datum type (*f*=0-1), while others have an *integer* datum type (*f*=5). Sending a datum in the improper format will result in an "N08" error response. Valid format types are shown in the following table:

f	**converts each *datum* parameter value (' *dddd'*) from..**			**max.char.**
0	1-10 digit signed decimal " [-xxx]x.[xxxxxx]"	to	single binary float	13
1	8-digit hex " xxxxxxxx"	to	single binary float	9
5	8-digit hex " xxxxxxxx"	to	long binary integer	9

The 2-character *array index* field (*aa*) is a **hexadecimal value** selecting a particular internal coefficient array to receive the downloaded data. The first *array index* (*aa*=01) refers to channel 1's transducer, the 16th (*aa*=10) refers to channel 16's transducer. Finally, the last array (*aa*=11) refers to a special global array.

A 2-character *coefficient index* field (*cc*) is a hexadecimal value that selects a particular coefficient within the specified array. Multiple contiguous coefficients may be specified by using a *coefficient index "range"* specified by adding a hyphen (negative sign) between two such indexes (*cc*-*cc*).

Transducer Coefficient arrays for internal channels 1-16 are selected with ***array indexes aa*=01 through *aa*=10 (hex).** A special single **Other Coefficient** array is selected with ***array index aa*=11 (hex).** All the valid *coefficient (cc) indexes* (for each of these arrays) are listed in the appropriate tables included in the description of the previous ***Read Internal Coefficients* ('u')** command.

Example:

- Send TCP/IP command to 9816 module (i.e., via its connected socket) with replacement values for the channel's offset and gain correction terms loaded into the module's volatile memory (cc = 00-01). Load these into channel # 8's **Transducer Coefficient** array (aa=08):

  "**v00800-01 0.000 1.000**"

  Response returned is:

  "A"

- Send command to 9816 module (via its connected socket) to change its default EU output from psi to kPa. This will be done by changing the **EU Pressure Conversion Scaler** to 6.894757.

  "V01101 6.894757"

  Response returned is

  "A"

SET/DO OPERATING OPTIONS/FUNCTIONS (Command 'w')

Purpose: Change a module's default operating option settings, or invoke special internal operations or functions.

Command	"**w*ii*[*dd*[*eeee*]]**" 'w' is the *command* letter. '*ii*' is the *index* field. '*dd*' is an [optional] hex *datum*. ' *eeee*' is an [optional] *extra datum* with leading *space* character.
Response	"**A**" 'A' is the *acknowledge* letter.

Description: The *index* field *(ii)* contains two hex digits that identify the specific option to be set or function to be performed. The *datum* field *(dd)*, when present, contains 2 hex digits. A few indexes also require an *extra datum* field *(eeee)*. Valid options/functions are listed in the table below (-- marks a missing *datum* field in its column, and fourth column shows any **'q'** command index that reads same option):

ii	***dd***	**Description**	**'q' read index**
00	--	Execute **Internal Self Test**.	
01	--	Update **Internal Thermal Coefficients**.	
02-06	--	Reserved for factory use	
07	--	Store **Most Operating Options** in nonvolatile flash memory. See *** Note at end of table.	
08	--	Store **Current *Offset* Terms i**n transducers' non-volatile memories. See *** Note at end of table.	
09	--	Store **Current *Gain* Terms** in transducers' non-volatile memories. See *** Note at end of table.	
0A	01-10 (1-16)	Set **Number of Channels in Module** (default =16).	
0B	00 01	Enable **Automatic Shifting of Calibration Valve** during ***Calculate and Set Offsets*** (**'h'**) command (default). Disable **Automatic Shifting of Calibration Valve** in **'h'**. User will manually control calibration value.	

ii	*dd*	Description	'q' read index
0C	00 01	Energize C2: **Set Cal Valves to RUN or LEAK Position** (default) — choice made by *ii*=12. Energize C1: **Set Cal Valves to CAL/RE-ZERO or PURGE Position** — choice made by ii=12.	0B **see chart below**
0D-0E	--	Reserved for factory use	
0F	00 01	Disable periodic **Thermal Coefficient Update** task. Enable periodic **Thermal Coefficient Update** task (default).	
10	01-FF (1-255)	Set **Number of A/D Samples to Average. (default = 8).**	05
11	--	Reserved for factory use	
12	00 01	Energize C4: **Set Cal Valves to RUN or CAL/RE-ZERO Position** (default) — choice made by *ii*=0C. Energize C3: **Set Cal Valves to PURGE or LEAK Position** — choice made by *ii*=0C.	0B **see chart below**
13	00 01	Use **Static IP Address Resolution** (default) Use **Dynamic IP Address Resolution**	06
14	00 01 02	Disable **TCP/IP Back-Off Delay** (default). Enable **TCP/IP Back-Off Delay** as low-order byte of Ethernet Adrs.(converted to decimal value * 20 µSec.). Enable **TCP/IP Back-Off Delay** specified per ***eeee*** as decimal value (* 20 µSec.)	07
15	--	Reserved for factory use	
16	00 01	Disable **TCP/IP Data Field Size Prefix** (default). Enable **TCP/IP Data Field Size Prefix** (2-byte big-endian binary value with total size of response data in bytes).	08
17	00	Set **TCP Connect Port** per ***eeee*** as decimal value (default=9000).	09
18	00 01	Disable **Auto UDP Broadcast@Reset** (default). Enable **Auto UDP Broadcast@Reset**.	0A
19	00 01	Set **Minimum Temperature Alarm Set Point** (in ^{0}C) per ***eeee*** as decimal value (default = 0 ^{0}C). Set **Maximum Temperature Alarm Set Point** (in ^{0}C) per ***eeee*** as decimal value (default = 60 ^{0}C).	0D 0E
1A	00	Set **External DH Scan Interval** per ***eeee*** as decimal value (seconds), 1 <= ***eeee*** <= 3600 (1 hour) (default = 60).	10

ii	*dd*	Description	'q' read index
1B	00	Set **Thermal Update Scan Interval** per ***eeee*** as decimal value (seconds), 1 <= ***eeee*** <= 3600 (1 hour) (default = 60).	11
1C	--	Reserved for factory use	
1D	00	Set **Minimum Source Air Pressure** per ***eeee*** as decimal value (in psi) (default = 60).	
1E	00 01	Enable **Source Air Check** (default) Disable **Source Air Check**	

*** **NOTE**: Modification of option index *ii* = 13, 14, 16, 17, 18, 19, 1A, or 1B will result in that specified operating option *immediately* becoming the new module Power-On default. However, for *most other* operating options to be retained after module power cycles, they must be explicitly saved when changed by function index *ii* = 07 to module Flash memory. Likewise, the *offset/gain coefficients* calculated by calibration commands **'h', 'Z'** or **'C'**, must be explicitly saved to transducer nonvolatile (EEPROM) memory (see indexes *ii* = 08/09 in table above).

The Valve Position indexes (*ii*=12 and *ii*=0C) each have two states (00/01) that when combined provide four (4) possible states of the C1/C2/C3/C4 internal valves. This "Logical Rotary Switch" with four (4) positions is summarized in the following chart:

	C1 Energized C2 Not (0C=01)	C2 Energized C1 Not (0C=00)
C3 Energized C4 Not (12=01)	**PURGE position**	**LEAK/CHECK position**
C4 Energized C3 Not (12=00)	**CAL/RE-ZERO position**	**RUN position**

Example:

- Send TCP/IP commands to 9816 module (via its connected socket) setting the calibration valve to the CAL (or Re-zero) position:

  "**w1200**" (Insure in RUN/CAL valve mode)
  "**w0C01**" (Set CAL position)

  Responses (both commands):

  "A"
  "A"

Note If programmer "knows" that module is already in RUN/CAL valve mode, the first command above is optional. For more information, see Chapter **4**, **Figure 4.5**.

NETWORK QUERY (UDP/IP Command 'psi9000')

Purpose: To determine how many (and which) modules are powered-up and operational on the network.

Command	"**psi9000**"
Response	***"ipadr, ethadr, sernum, mtype, fmwver, connst, ipadrst, lisport, subnet, iparpst, udpast, pwrst, rack, cluster, slot,"***

Description: When a **NetScanner™ System** module receives this broadcast command (by continuously monitoring port 7000) it responds with a broadcast (on port 7001) with an ASCII response containing comma-separated parameters. These are listed in the following table:

parameter	meaning
ipadr	**IP Address**
ethadr	**Ethernet Address**
sernum	**Serial Number**
mtype	**Module Type** (e.g., = 903x)
fmwver	**Firmware Version** (e.g., = 4.30)
connst	**Connection Status** (1=connected, 0=available)
ipadrst	**IP Address Status** (1=has one, 0=waiting for server)
lisport	**TCP Connect Port** (default = 9000)
subnet	**Subnet Mask**
iparpst	**IP Address Resolution Method** (1=use RARP/BOOTP server, 0=use static IP Address stored internally)
udpast	**UDP Auto Status** (1=broadcasts this response automatically after connection possible, 0=only sends response for "psi9000" UDP/IP command.
pwrst	**Power Up Status** (same a 'q02' command response)
rack	**Rack** 0-F (0-15) of 98RK-1 chassis
cluster	**Cluster** 0-F (0-15) of 98RK-1 chassis
slot	**Slot** 1-8 of Model 9816 module in 98RK-1 chassis

Only **NetScanner™ System** 9816 module types have the extra Cluster, Rack, and Slot parameters to the response above (note RCS order instead of CRS order).

This uniform network query response allows a client host program to identify, configure, and use any suitable group of modules (for the task at hand) by simply opening a TCP/IP connection between itself and each available module needed.

Example:

- Query all module(s) on then network.

  "psi9000"

  Response(s):

  (See response above)

RE-BOOT MODULE (UDP/IP Command 'psireboot')

Purpose: To unconditionally "reboot" a specified module.

Command	"**psireboot *ethadr***" where *ethadr* is the Ethernet Address of the specified module in the following special hex-digit format 'xx-xx-xx-xx-xx-xx'
Response	none (module reboots).

Description: When a **NetScanner™ System** module receives this broadcast command (by continuously monitoring port 7000) it responds by restarting its firmware immediately. The result is essentially the same as a power up restart, in that any TCP/IP connection is lost, and the module returns to its normal startup state. The host must wait long enough for the reboot process to be completed before is can again address the module.

Example:

- Reboot a specified module on then network.

  "psireboot 12-34-56-78-90-12"

  Response:

  (None)

CHANGE MODULE'S IP ADDRESS RESOLUTION METHOD & RE-BOOT (UDP/IP Command 'psirarp')

Purpose: To change (toggle) the current IP address resolution state (*ipaarpst*) of a specified module, and then unconditionally "re-boot" it.

Command	"**psirarp *ethadr***" where *ethadr* is the Ethernet Address of the specified module in the following special hex-digit format 'xx-xx-xx-xx-xx-xx'
Response	none (module reboots).

Description: When a **NetScanner™ System** module receives this broadcast command (by continuously monitoring port 7000) it responds by toggling its current ARP method to one of two states: dynamic resolution or static resolution. Then it restarts its firmware. The result is essentially the same as a power up restart, in that any TCP/IP connection is lost, and the module returns to its normal startup state. However, if it used the static resolution method before it received this command, after the reboot it will not have a valid IP Address until an external network server (RARP or BOOTP) provides it with one. However, executing the command a second time will restore it to using its original statically assigned IP address (after another reboot finishes).

Just as for the "psireboot" command, the host must wait long enough for the reboot process to be completed before it can again address the module.

Example:

- Reconfigure a specified module on the network so that it uses its "other" IP Address Resolution method, and also reboot it. Presumably, it knew the module's current state (*iparpst*) as result of a recent Network Query response from the module.

  "psirarp 12-34-56-78-90-12"

  Response:

  (None)

Chapter 4

Calibration

4.1 Introduction

Each individual DH200 transducer within the **NetScanner™ System** Intelligent Pressure Scanner contains nonvolatile read/write memory capable of storing the transducer's full thermal and pressure calibration data. The internal firmware of each module reads all of these calibration data from each transducer upon power up and then dynamically calculates conversion coefficients that convert transducer output into pressure at the current measured temperature. The firmware uses these coefficients for all subsequent engineering-unit data conversions performed.

All **NetScanner™ System** Intelligent Pressure Scanner modules use a third-order polynomial to convert transducer output voltage to pressure. All calculations are carried out internally using high precision math. The following formula is used for all pressure output calculations.

$$P_T(V) = [C_0(T) + C_1(T)*V + C_2(T)*V^2 + C_3(T)*V^3] * C_{SPAN} + C_{RZ}$$

where:

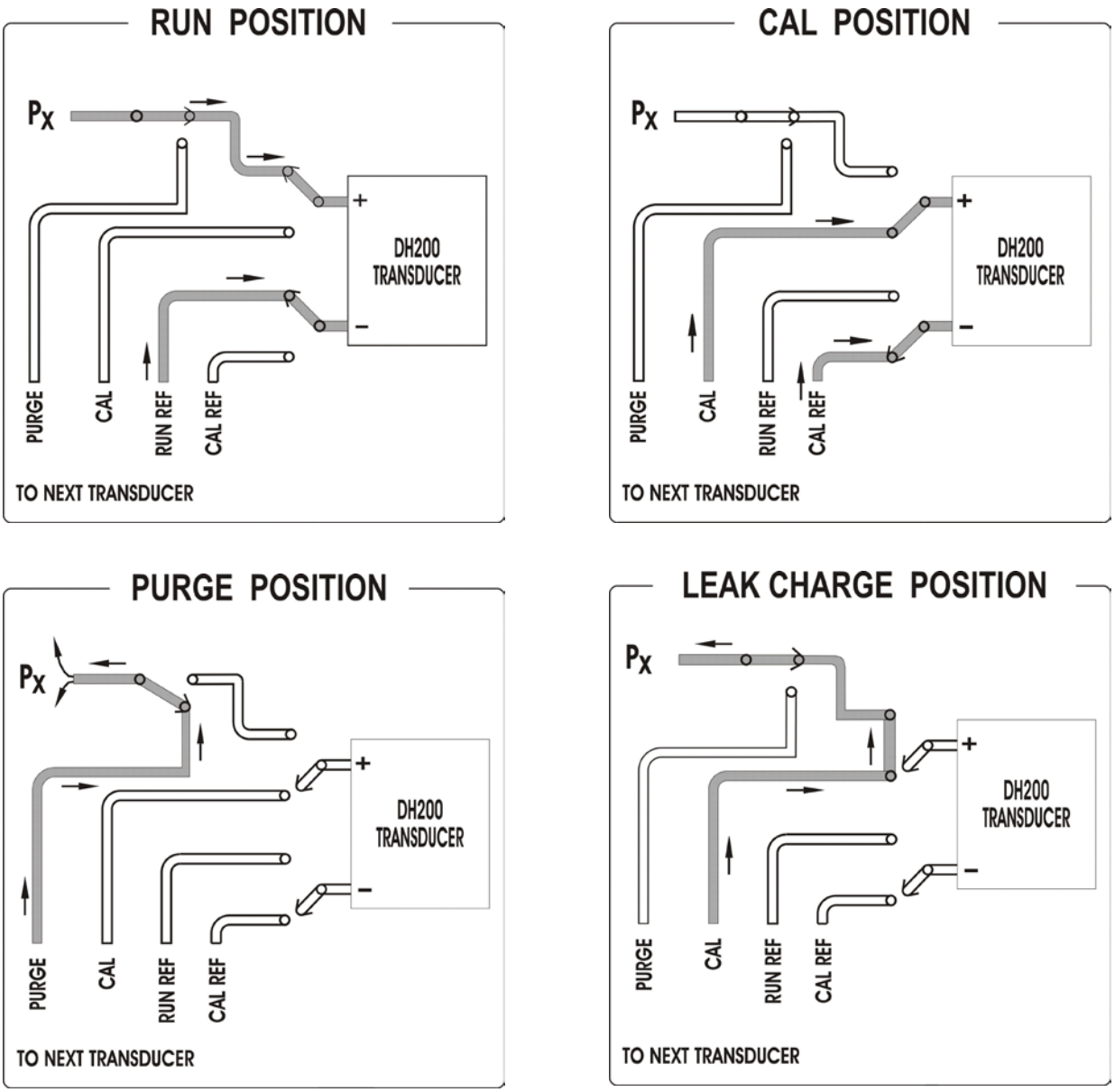
P_T	=	Calculated applied pressure
V	=	Transducer output voltage
$C_0(T)$ .. $C_3(T)$	=	Conversion coefficients generated from calibration data at temperature T.
C_{RZ}	=	Re-zero adjustment's "*offset*" correction coefficient
C_{SPAN}	=	Span adjustment's "*gain*" correction coefficient

Since the polynomial's coefficients are a function of the current temperature, they are dynamically re-calculated by the module firmware (with other equations) to compensate for each transducer's measured temperature change.

Each model 9816 Intelligent Pressure Scanner contains an integral purge/leak check calibration manifold. Through software commands to each 9816, this valve may be placed in one of four positions: **RUN, CAL, PURGE,** or **LEAK-CHARGE**. (See the **Set/Do Operating Options/Functions ('w')** command (*ii*=0C & 12) in **Chapter 3**, and in particular the **Valve Position Chart** at the end of command's description.) The 98RK-1 contains pneumatic backplane inputs for **CAL (CAL 1-8)** and **CAL REF**. When each module's internal calibration valve is placed in the **CAL/RE-ZERO** position (through software commands), all DH200 transducer *pressure* inputs are pneumatically connected to the **CAL** input ports. All DH200 *reference* inputs are pneumatically connected to the **CAL REF** input port. The **CAL** input may be used to perform on-line zero adjustment of the transducers. This capability virtually eliminates sensor zero drift error and ensures the highest possible data accuracy. The **CAL** input may also be used for DH200 span adjustment calibrations. Span calibration of multi-range scanners may also utilize the **CAL 1-8** ports if the highest applied pressure does not exceed the proof pressure rating of any installed transducer.

Note **Periodic zero and span calibration should be the only calibration required to maintain specified performance throughout the life of the scanner.**

For reference when operating the 9816 calibration manifold, Figures 4.1 thru 4.4 show simplified pneumatic diagrams of the calibration manifold in its various operating positions.



Figures 4.1 – 4.4
Pneumatic Diagrams of the Calibration Manifold

4.2 Re-zero Calibration

NetScanner™ System Intelligent Pressure Scanners are capable of independently performing a transducer calibration adjustment function, referred to as *Re-zero adjustment* (or simply Re-zero Cal). The Re-zero calibration will result in a recalculated "offset" coefficient for each channel being calibrated, which automatically compensates for any transducer offset drift errors. Since the factory-set coefficients in each transducer (that characterize both pressure and temperature) are extremely stable over time, these simple offset corrections compensate for the majority of transducer errors over time. For this reason, a Re-zero may be the only calibration adjustment required by many applications. For those with applications requiring more accuracy, an optional *single-point Span-only* calibration adjustment will be described in **Section 4.3.** An improved *multi-point calibration* adjustment, integrating both the Re-zero and Span calibration process, will be described in **Section 4.4.**

For the **Model 9816**, with its integral DH200 pneumatic transducers, internal manifolds and valves allow a Re-zero calibration to be accomplished easily and automatically.

Before executing the Re-zero calibration adjustment function, a stable 0.0 psi differential pressure should be applied to the appropriate CAL (x) and CAL REF input port of the **98RK-1**. Unless the optionally-specified *pressure* parameter of the *Calculate and Set Offsets* ('h') command (described fully in **Chapter 3**) is used, the 9816 will assume 0.0 psi is applied to the affected channels.

When instructed to execute a ***Calculate and Set Offsets*** ('**h**') command, the **NetScanner™ System** module will automatically perform the *Re-zero adjustment* calibration, and then update the *offset coefficients* in its volatile memory. It will subsequently use the newly calculated terms for all future engineering-unit calculations.

Note

When using the *Calculate and Set Offsets* ('h') command, only local terms in the module's volatile main memory (RAM) are updated. Under normal operation, it is not recommended to store these new coefficients in transducer non-volatile memory. Instead, the re-zero should be performed at regular intervals. Refer to Section 4.5 if it is desired to also store these *new offset* coefficients in transducer nonvolatile memory.

4.2.1. Re-zero Calibration Valve Control

When instructed to execute a Re-zero (**Calculate and Set Offsets** (**'h'**) command), Model 9816 modules will normally shift the internal calibration valve into the **CAL** position and use the pressures present at the **CAL** and **CAL REF** inputs for the "minimum" (e.g., zero) calibration pressure. After the Re-zero adjustment is complete, the calibration valve will be placed in the **RUN** position. This automatic shift of the calibration valve can be disabled through use of the **Set Operating Options** ('**w**') (option index=0B hex) command. This allows independent control of the calibration valve by the user using other options (see *option indexes* = 0C and 12 hex) of the same command.

4.2.2 Re-zero Calibration Summary

The following is a simple, step-by-step procedure for executing a re-zero calibration of a **Model 9816 Intelligent Pressure Scanner**. Optional commands are shown within brackets [ ].

Description	TCP/IP Data
Disable automatic valve shifting after module power up. Insure that valves in RUN/CAL mode (default).	[w0B01] [w1200]
… normal data acquisition	
Apply 0.0 psi differential to the appropriate CAL x and CAL REF inputs on the back of the 98RK-1	
Place the module calibration manifolds into the CAL position [if w0B01 command executed in step 1]	[w0C01]
Delay for settling of pneumatic inputs	
Verify that measured data reads near expected zero value	[rFFFF0]
Instruct module to calculate new *offset* coefficients for all 16 channels	hFFFF
Place calibration manifold back into the RUN position [if w0B01 command executed in step 1]	[w0C00]
Store new *offset* coefficients into transducer nonvolatile memory	[w08]
… continue normal data acquisition	

4.3 Span Calibration

For improved accuracy, **NetScanner™ System** Intelligent Pressure Scanners are capable of independently performing a transducer calibration function, referred to as *Span adjustment* (or simply Span Cal). Actually, there is a provision to supply any suitable "upscale" pressure (e.g., actual transducer full-scale) during such a calibration adjustment. The *Span adjustment* calibration will result in a recalculated "gain" coefficient for each channel being calibrated, to compensate for any transducer or module gain errors. For best results, a Re-zero calibration should be performed before performing a span calibration. Also, note that a new and improved **Multi-Point Calibration** function exists (for modules with firmware version 2.24 of higher). This function integrates the separate calibration functions (for Re-zero and Span adjustment described in **Section 4.2** and this section) into a single function that adjusts both "offset" and "gain" coefficients at the same time, using two **or more** calibration points. Details of using this improved calibration function are described in **Section 4.4.**

For **Model 9816**, with integral DH200 transducers, internal manifolds and valves allow a Span adjustment pneumatic calibration to be accomplished easily and automatically.

It is recommended that a *Span adjustment* be performed whenever new transducers are installed in the instrument. In such cases, the resulting new *gain* coefficients should always be

stored back into the transducer's nonvolatile memory afterwards. In other cases, the user's application may not require periodic span adjustment as the other factory-determined pressure/temperature coefficients (stored permanently inside each transducer) are extremely stable. Only an occasional *Re-zero adjustment* may be all that is necessary.

When instructed to execute a ***Calculate and Set Gains*** (**'Z'**) command, the module will perform the *Span adjustment* calibration, and then update the *gain coefficients* in its volatile memory. It will subsequently use the newly calculated *gain* terms for subsequent engineering-unit calculations.

Note

When using the *Calculate and Set Gain* ('Z') command, only the local variables in the module's volatile main memory (RAM) are changed. Refer to Section 4.5 if it is desired to also store these new *gain* coefficients in transducer nonvolatile memory.

4.3.1. Span Calibration Valve Control

Before executing a Span adjustment (***Calculate and Set Gains*** (**'Z'**) command), Model 9816 modules should have their calibration manifold valve placed in the proper position. For single pressure range units, the **CAL** position should be used since the span calibration pressure can be applied between the **CAL 1-8** and **CAL REF** ports. Since the module will not attempt to shift this valve automatically, as it does for Re-zero adjustment, it should be placed in the desired position ***manually*** with the ***Set Operating Options*** (**'w'**) command (option indexes = 0C and 12).

When span calibrating Model 9816 modules with *multiple ranges* installed, the **CAL** port may be used to apply pressure to all transducers **only if the specified proof pressure is not exceeded on any channel.** If the application of a specific span pressure exceeds the proof pressure rating of any other transducer contained within the same scanner, the calibration pressures must be applied to the **RUN** side pneumatic input ports. Since the calibration command (**'Z'**) has a *channel selection bit map* parameter allowing it to calibrate only the desired pressure channels, the RUN port is a viable option for supplying the calibration pressures.

Pneumatic Connector Assignment on Rear Input Panel of the 98RK-1

Connection	Pressure Scanner Range Input
Cal 1	User defined
Cal 2	10" W.C.; 20" W.C.; ±1 psid, ±1.5 psid
Cal 3	±2.5; ±5 psid
Cal 4	±10; ±15 psid, ±20 psid, ±25 psid
Cal 5	±30; ±45; ±50 psid
Cal 6	±75 psid, ±100 psid
Cal 7	+ 150; 200; 250; 300 psid
Cal 8	500 psid, 600 psid, 650 psid, 750 psid, 850 psid

Note

To minimize the possibility of overpressure damage, multi-range 9816 modules are manufactured to make use of the CAL (x) port of the LOWEST installed pressure range.

4.3.2. Span Calibration Summary

Following is a simple, step-by-step procedure for executing a "full scale" span calibration of a 9816 Intelligent Pressure Scanner. It is assumed that all channels in the unit have the same full-scale pressure range. Optional commands are shown within brackets [ ].

Description	TCP/IP Data
Insure that valves in RUN/CAL mode (default).	[w1200]
… normal data acquisition	
Perform Re-zero calibration	see **Sec. 4.2.2**
Place the module calibration manifolds into the CAL position if this is the desired pressure application input. The RUN position may be a better choice for modules with transducers having different ranges.	[w0C01] for CAL pos. [w0C00] for RUN pos.
Apply exact full scale pressure to the appropriate module CAL and CAL REF inputs [or optionally to RUN inputs]	
Delay for settling of pneumatic inputs	
Verify that measured data reads near expected full scale	[rFFFF0]
Instruct module to calculate new *gain* coefficients for all 16 channels	ZFFFF
Place calibration manifold back into the RUN position	w0C00
Store new *gain* coefficients into transducer nonvolatile memory	w09
… continue normal data acquisition	

Following is a simple, step-by-step procedure for executing a "specified-value" span calibration of a **Model 9816 Intelligent Pressure Scanner**. For the purposes of this example, it will be assumed that an upscale pressure of 14.9800 psi is available from a dead weight tester for the calibration of 15 psi internal transducers. All sixteen channels are 15 psi full scale.

Description	TCP/IP Data
Insure that valves in RUN/CAL mode (default).	[w1200]
… normal data acquisition	
Perform Re-zero calibration *first*	see **Section. 4.2.2**
Place the module calibration manifolds into the CAL position if this is the desired pressure application input. The RUN position may be a better choice for modules with transducers having different ranges.	[w0C01] for CAL pos. [w0C00] for RUN pos.
With a deadweight tester, apply 14.9800 psi to the appropriate module CAL and CAL REF inputs [or optionally to RUN inputs]	
Delay for settling of pneumatic inputs	
Verify measured data reads near expected full scale.	[rFFFF0]
Instruct module to calculate new gain coefficients for all 16 channels	ZFFFF 14.98
Place calibration manifold back into the RUN position	w0C00
Store new gain coefficients to transducer nonvolatile memory	w09
… continue normal data acquisition	

4.4 Integrated Multi-Point Calibration Adjustment

NetScanner™ System Intelligent Pressure Scanners may have their accuracy enhanced by regular application of one or both of the individual *Re-zero* and *Span* calibration adjustment functions already described in **Sections 4.2** and **4.3**. For users who have installed scanner firmware version 2.24 or later, an integrated and more comprehensive **Multi-Point Calibration** function may be used instead to adjust the same *offset* and *gain* coefficients for a module's channels. This function also provides for supplying additional calibration points, which is particularly useful when it is desired to fit the adjustment data to the entire negative and positive range of the module. This integrated calibration adjustment function is fully described in this section. It is implemented by four (4) sub-commands of the **'C'** command. Since this function combines the functions of the Re-zero and Span calibration adjustments (using the **'h'** and **'Z'** commands) it is recommended that you read the information of **Section 4.2** and **4.3** before attempting to perform this multi-point calibration.

It is recommended that a **Multi-Point Calibration** *adjustment* be performed whenever new transducers are installed in your module. In such cases, the new *zero* and *gain* coefficients that

result should always be restored into the transducer's non-volatile memory afterwards. In some cases, the user's application may not require such a comprehensive adjustment as the other factory-determined pressure/temperature coefficients (stored permanently inside each transducer) are extremely stable. Only an occasional *Re-zero adjustment* may be all that is necessary.

When instructed to execute a particular sequence of sub-commands of the ***Configure Multi-Point Calibration*** (**'C'**) command, the module will perform the various stages of the *Multi-Point Calibration adjustment* calibration function, and then update both the *offset and gain coefficients* in the module's volatile (e.g., RAM) memory. The module will use this newly calculated data term for all subsequent engineering-unit calculations.

Note **When using the *Configure/Control Multi-Point Calibration* ('C') coefficients in transducer non-volatile memory.**

4.4.1. Calibration Valve Control

Before executing a **Multi-Point Calibration** adjustment (using various forms of the ***Configure/Control Multi-Point Calibration*** (**'C'**) command), Model 9816 modules should have their calibration valve placed in the proper position. For modules with only one common pressure range for its transducers, the **CAL** position should be used since the span calibration pressure can be applied between the **CAL 1-8** and **CAL REF** ports (see **Section 4.3.1** for more information on these ports). Since the module will not attempt to shift this valve automatically, as it does for Re-zero adjustment, it should be placed in the desired position ***manually*** with the ***Set Operating Options*** (**'w'**) command (option indexes = 0C and 12). This is illustrated in the example of the next section.

When multi-point calibrating Model 9816 modules with *multiple ranges* installed, the **CAL** port may be used to apply pressure to all transducers **only if the specified proof pressure is not exceeded on any channel.** If the application of a specific span pressure exceeds the proof pressure rating of any other transducer contained within the same scanner, the calibration pressures must be applied to the **RUN** side pneumatic input ports. Since the calibration command (**'C'**) has a *channel selection bit map* parameter allowing it to calibrate only the desired pressure channels, the RUN port is a viable option for supplying the calibration pressures.

4.4.2 Multi-Point Calibration Summary

Following is a simple step-by-step procedure for executing a "multi-point" calibration of a **Model 9816 Intelligent Pressure Scanner**. It is assumed that all channels in the unit have the same full-scale pressure range. Optional commands are shown within brackets [ ]. If it should become necessary to abandon this calibration procedure once it is started, you may execute the Abort sub-command [C 03] of 'C' at any time after the first 'C' sub-command.

Description	TCP/IP Data
Insure that valves in RUN/CAL mode (default).	[w1200]
… normal data acquisition assumed to be running	
Place the module calibration manifolds into the CAL position if this is the desired pressure application input. The RUN position may be a better choice for modules with transducers having different ranges.	[w0C01] for CAL pos. [w0C00] for RUN pos.
Ready the module for multi-point calibration by executing the Configure & Start ('00') sub-command of 'C'. This establishes all the channels to be affected, and determines the total number of calibration points that will be supplied (3 in this example) in later steps. It also starts module averaging for calibration (64 samples in this example). The linear fit (1) is required.	C 00 FFFF 3 1 64
Apply 1st calibration pressure to the module's CAL or RUN inputs. The zero (0.0) point is assumed in this case. After applying zero pressure verify that this pressure is measured correctly by the module.	[rFFFF0]
When the data are stable, enter the *Collect Data* ('01') sub-command of 'C' specifying this first calibration point (1) with zero pressure (0.0).	C 01 1 0.0
Apply 2nd calibration pressure to the module's CAL or RUN inputs. A full-scale (+5 psi) point is assumed in this case. Verify that pressure reads correctly.	[rFFFF0]
When the data are stable, enter another *Collect Data* ('01') sub-command of 'C' specifying this second calibration point (2) with 5.0 psi pressure.	C 01 2 5.0
Apply 3rd calibration pressure to the module's CAL or RUN inputs. A mid-scale negative (-2.5 psi) point is assumed in this case. A vacuum pump is normally required to achieve such a pressure with 903x calibrators. Verify that measured pressure reads correctly.	[rFFFF0]
When the data are stable, enter last *Collect Data* ('01') sub-command of 'C' for this point (3) with a negative (-2.5 psi) pressure.	C 01 3 -2.5

Now that data have been collected for every point originally specified, calculate and apply the new coefficient data with a *Calculate & Apply* ('02') sub-command of 'C'. This also restores the module to using its original averaging parameters that existed before the first 'C' command.	C 02
Place calibration manifold back into the RUN position, if the CAL position was used.	[w0C00]
Store new *offset* and *gain* coefficients into transducer non-volatile memory.	w08 w09
… continue normal data acquisition.	

4.5 Coefficient Storage

The various calibration functions described in **Sections 4.2** and **4.3** update the active *offset* and *gain* coefficients, respectively, in the module's volatile main memory (RAM) only. These newer calibration coefficients will be lost when instrument power is turned off. The **Set Operating Options** (**'w'**) command may be used to also store these coefficients back in each transducer's nonvolatile memory. This command's *option index* = 08 will store new *offset* coefficients, while its *option index* = 09 will store new *gain* coefficients.

A user may read (and should verify) any new *offset* and/or *gain* coefficients after performing each calibration adjustment command (i.e., by saving coefficient data returned in a command **'h'** or **'Z'** response), or the **Read Internal Coefficients** (**'u'**) command may be used to read them any time after calibration adjustment commands have been performed (see coefficient indexes *cc*=00 and 01 for arrays *aa*=01 through 10). These "adjusted" coefficients may be verified, and then saved by storing them in each transducer's non-volatile memory with the **'w'** command described above. Alternately, they may be verified and stored on the host computer's secondary storage, and later restored (if necessary) with the **Download Internal Coefficients ('v')** command (same array/coefficient indexes as **'u'**).

4.6 Line Pressure Precautions

When operating 9816 pressure scanners at elevated line or reference pressures, care must be taken when any command is issued that may result in shifting of the calibration valve. The user must ensure that any valve shifts will not result in the internal DH200 transducers being exposed to pressure transients that may exceed the proof pressure rating of the transducer. This is especially important when operating at elevated reference pressures as a shift to the **CAL** position may result in a rapid pressure change if the **CAL/CAL REF** pressure varies greatly from the measurement reference pressure.

Chapter 5

Service

5.1 Maintenance

This section provides a step-by-step guide for performing repair and maintenance of typical **NetScanner™ System** Intelligent Pressure Scanners installed in the **98RK-1 Scanner Interface Rack**. The method of upgrading module firmware is also presented in **Section 5.2.**

Figure 5.1 is an exploded view of the Model 9816 calibration manifold. **Figure 5.2**, (next page) depicts **Model 9816** with and updated purge block. Please refer to this drawing for an understanding of the construction of all Intelligent Pressure Scanner models internally-mounted in the **98RK-1 Scanner Interface Rack**.

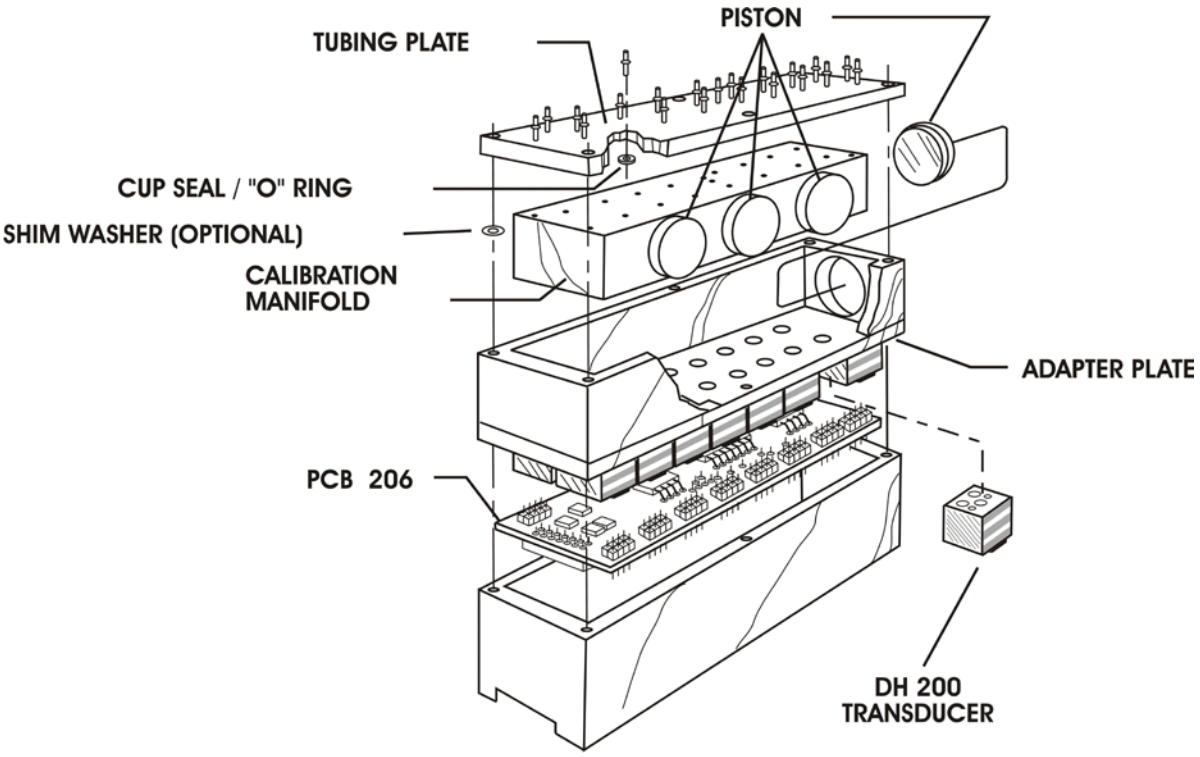


Figure 5.1
Exploded View of 9816 Calibration Manifold

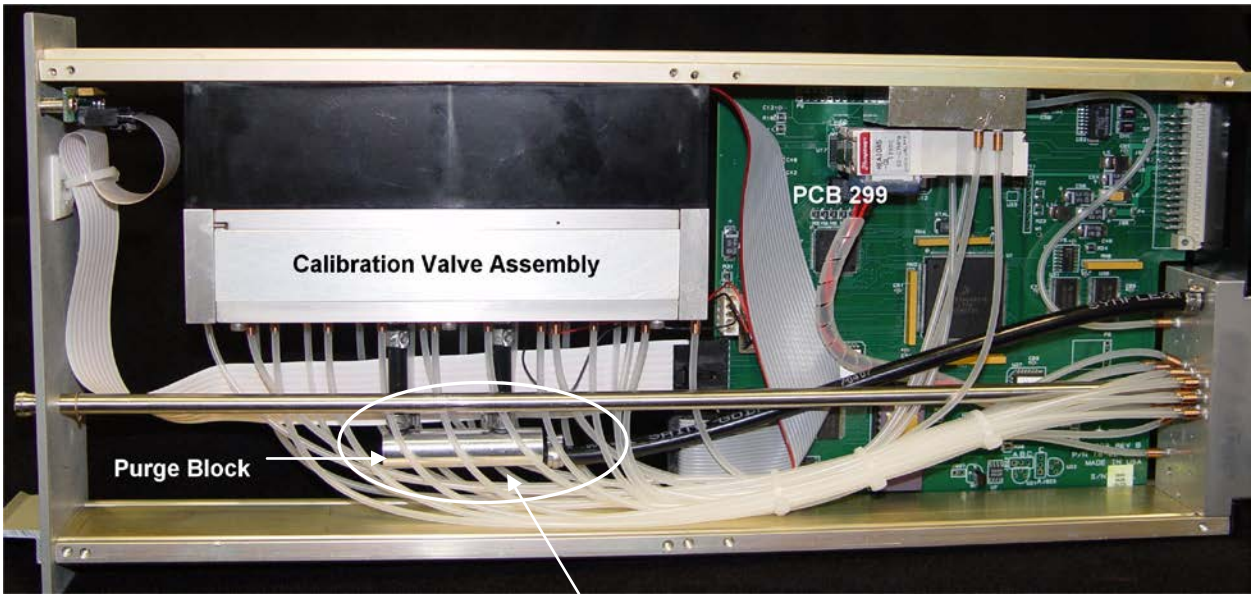


Figure 5.2
9816 with Upgraded Purge Block

Table 5.1 provides a convenient cross reference summary of components and printed circuit boards found in each 9816 Intelligent Pressure Scanner as well as the 98RK-1 Scanner Interface Rack. This may be used as a guide to identify appropriate component replacement and maintenance sections in this chapter.

Component	Section
PC-206 Amplifier/MUX PCB Assembly	5.1.3.1
PC-299 Microprocessor PCB Assembly	5.1.3.2
PC-300 Valve Position PCB	5.1.3.3
PC-295 LED PCB	5.1.3.4
Internal DH-200 Transducers	5.1.4
Internal Solenoid Valves	5.1.5
Internal Pneumatic Calibration Manifold	5.1.6.4
PC-363 Ethernet Controller board (not field replaceable) (Front Pull-out Panel)	5.1.7

Table 5.1: Component Cross Reference

5.1.1 Common Maintenance

The **NetScanner™ System** Intelligent Pressure Scanners are designed for rugged use. No special preventive maintenance is required, although periodic maintenance may be required to replace worn or damaged components. Upgrades or modifications of module hardware or firmware may also be periodically required. For users who wish to do their own maintenance and repair, maintenance kits and replacement parts may be purchased from the factory.

When performing any type of maintenance of NetScanner™ System components, the following guidelines and precautions should always be followed :

- **Verify that the work area and technicians are properly grounded to prevent damage to electronic components due to electrostatic discharge.**
- **Ensure that all electrical and pneumatic connections have been removed from the module.**
- **Ensure that the work area is free of dust and other possible contaminants that may affect the high tolerance machined parts (and pneumatic seals, if model has an integral manifold).**
- **Care must be taken to prevent contaminants from reaching O-ring surfaces. If O-ring surfaces require cleaning, use a lint-free applicator with alcohol, Freon, or acetone to remove dirt and lightly lubricate the O-ring surface with silicon oil. The oil is not provided in the maintenance kit.**
- **Never use sharp objects to cut tubing from the bulged tubes. The tiny scratches left on the tubes could cause leaks.**

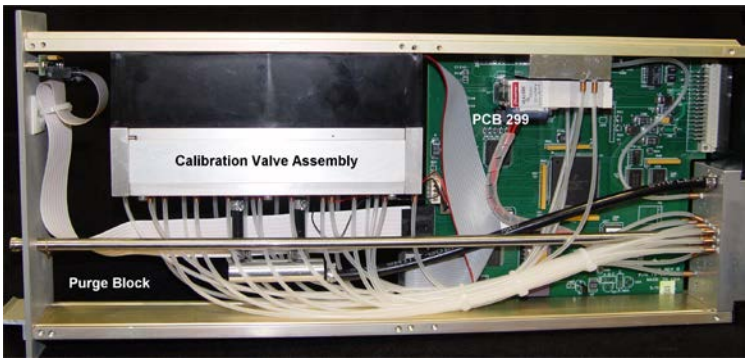
In the process of performing general maintenance on a module and in printed-circuit board replacement, the following tools may be required:

- 3/32" and 5/64" Allen-head screwdrivers,
- 3/16" hex wrench,
- needle nose tweezers,
- #0 Phillips-head screwdriver, and
- small adjustable wrench.

5.1.2 Module Disassembly

The following procedure should be used to remove modules from the 98RK-1 Scanner Interface Rack prior to any scanner maintenance.

(1) Remove the module from the **98RK-1 Scanner Interface Rack** by unscrewing the locking rod (turn counterclockwise with a 5/64" Allen-head screwdriver) and slide the entire module chassis out of the rack.



(2) Place the scanner on a flat surface. Remove the six (6) #0 Phillips-head screws that hold each of the side covers on the scanner. Remove one or both side covers (if your maintenance requires removal of both sides). Place the scanner with its front toward you. Notice that the locking rod holes are drilled slightly off-center of the panel and that the rod extends to the side of the tubing cluster. This facilitates removal of the transducer/cal-valve housing when maintenance needs to be performed. Note, **DO NOT** completely remove the locking rod unless there is an overriding need to do so. The *small* "c" spring clamp requires a special tool for removal and the clamp itself is easily lost.

(3) If your maintenance requires doing so, unplug the manifold position detector four-pin connector from the PC-299 board at P-12 (see **Figure 5.3** below).

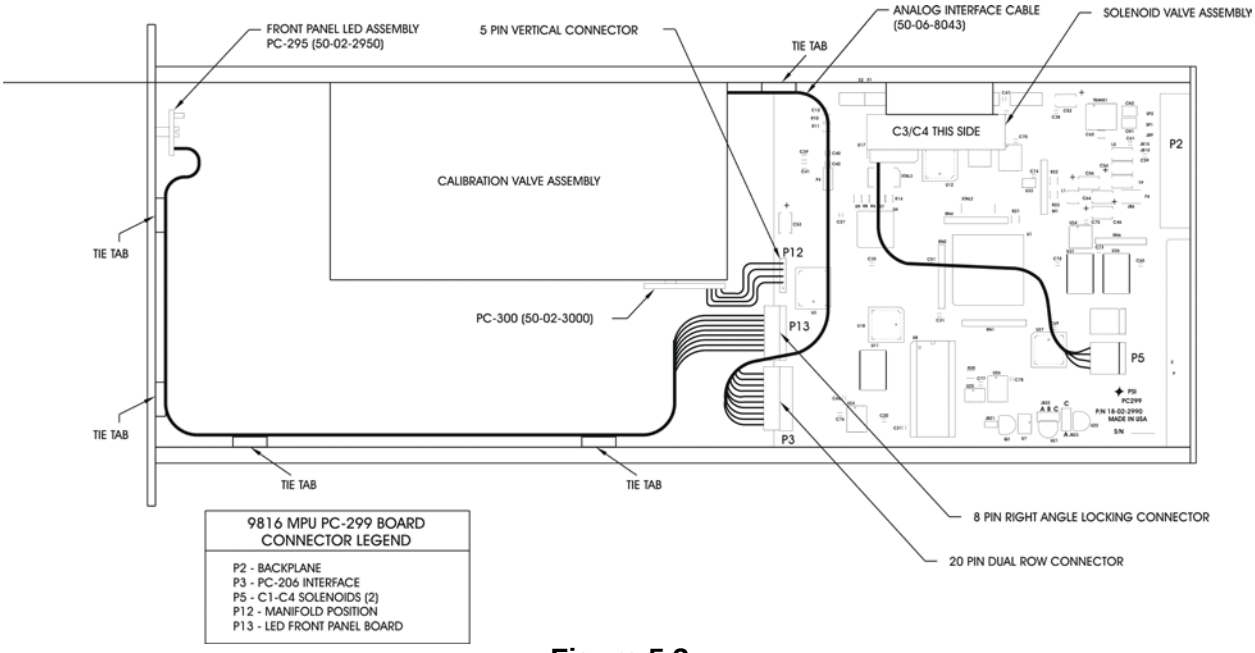


Figure 5.3
PC299 Board

(4) With one hand holding the transducer/cal-valve housing, remove the four (4) 3/32" Allen-head screws that secure the module to the scanner chassis top guide rail. Cut the nylon tie wrap that secures ribbon cable from the PC-206 board to the chassis. The chassis itself acts as the mounting plate for the scanner. When the four (4) screws are removed, the PC-206 Amplifier/MUX PCB assembly is exposed. Underneath the PC-206 PCB are the DH-200 transducers. Care must be taken that the loosened transducer/cal-valve housing does not fall down on the scanner locking rod.

(5) When all four (4) screws have been removed, shift the transducer/cal-valve housing to the side away from the chassis locking rod. Prop the transducer/cal-valve housing so that the ribbon cable from the PC-206 amplifier/multiplexer board is toward the back of the module. Care must be taken to ensure that the nylon tubes do not become crimped.

(6) Gently lift the transducer housing up and off the transducers and the amplifier/multiplexer board.

(7) You now have direct access to the electronic components in the scanner. Replace the bad component. *Remember that the amplifier/multiplexer board is sensitive to static discharge.*

(8) Replace the transducer/cal-valve and its housing exactly opposite the removal steps. For example, replace the transducer housing over the transducers and the amplifier/multiplexer board. With one hand holding the transducer/cal-valve housing, place the scanner up-right. Shift the transducer/cal-valve housing back into the scanner chassis. Align the Allen-head screws with the same holes from which they were removed, and tighten. Make sure not to pinch the electrical ribbon cable. Secure the ribbon cable to the top guide rail with a nylon tie.

(9) Replace the side panel(s) and test your scanner to ensure proper operation.

5.1.3 Electronic Circuit Board Replacement

Please refer to **Table 5.1** for a summary of applicable electronic circuit boards for your **NetScanner™ System** Intelligent Pressure Scanner.

5.1.3.1 PC-206 Amplifier/Multiplexer Board

The following procedures should be used for replacement of the PC-206 Amplifier/Multiplexer Board. Use the tools and follow the general precautions described in **Section 5.1.1**.

(1) Remove the scanner module from the 98RK-1 and disassemble it as described in **Section 5.1.2.** Remove the transducer/cal-valve housing from the top chassis rail. Carefully remove the ribbon cable from connector P1 of the PC-206 board. Note the orientation of the PC-206 relative to the rest of the module to ensure the new PC-206 is installed in the same position. See **Figure 5.4**, next page.

(2) Remove the two (2) Phillips-head screws securing the PC-206 board to the DH200 transducers. Carefully disconnect the PC-206 board from the DH200's by slowly working the board off the DH200s, starting at one end and moving down the length of the board. It is important that the gold pins are not bent when removing the board.

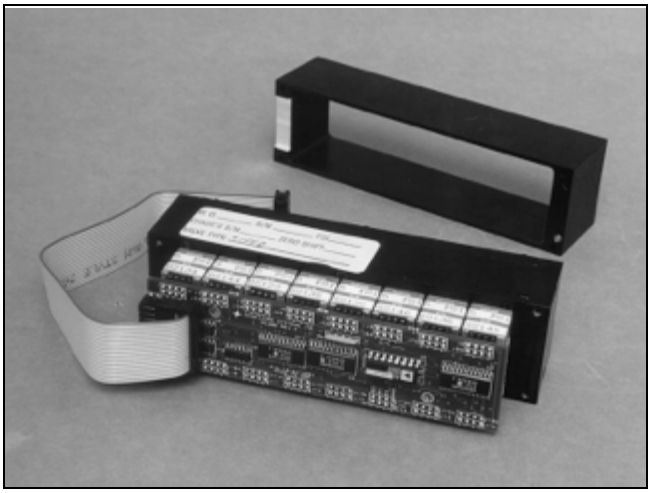


Figure 5.4
9816 Calibration Valve Out of its Case
(Showing PC-206 Board)

(3) Replace the old PC-206 board with a new one by placing the new one loosely on top of the DH200's. Ensure the new board end containing connector P1 is oriented the same as the old one. Inspect and make sure that all the gold pins fit easily into the female ends of the connectors on the DH200 transducers. Press the board down evenly until all pins are firmly seated.

(4) Install the two (2) Phillips-head screws to secure the PC-206 to the DH200s. Be careful not to over-tighten. Install the ribbon cable to connector P1 of the PC-206, **ensuring proper pin 1 location. (Pin 1 of the ribbon cable has a red stripe while pin 1 of P1 will contain a square solder pad on the PC-206.)**

(5) Re-install the calibration manifold into its chassis in accordance with the procedures in **Section 5.1.2.** Ensure that the PC-206 wiring harness extends through the notch in the top of the transducer/cal-valve housing and is not pinched.

(6) Replace the four (4) screws that secure the calibration manifold housing to the chassis and tighten. Do not over-tighten; 7-9 inch-pounds of torque should be sufficient.

(7) Test your scanner to ensure proper operation.

5.1.3.2 PC-299 Ethernet Microprocessor/A-D Board

The following procedures should be used for replacement of the PC-299 Ethernet Microprocessor/A-D Board. Use the tools and follow the general warnings already described in **Section 5.1.1.** The PC-299 microprocessor board fits inside the top and bottom bracket rails.

(1) Disassemble the module as described in **Section 5.1.2.1** and **5.1.2.2**.

(2) Carefully remove the four (4) attached wiring harnesses from connectors P3, P5, P12, and P13 on the PC-299 board.

(3) Remove the four (4) Allen-head screws securing back panel to the ***top and bottom*** rails. Slide the PC-299 board to clear the rear panel P-2 cutout. Carefully lift the board out from the rails. See **Figure 5.5 and Figure 5.6.**

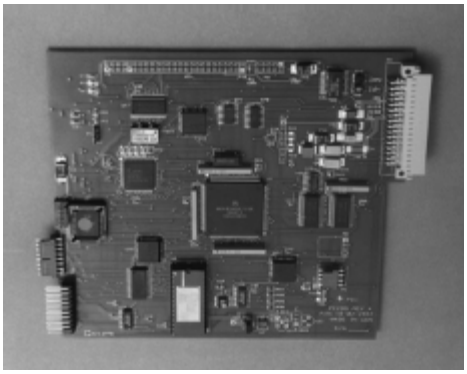


Figure 5.5
PC-299 Board

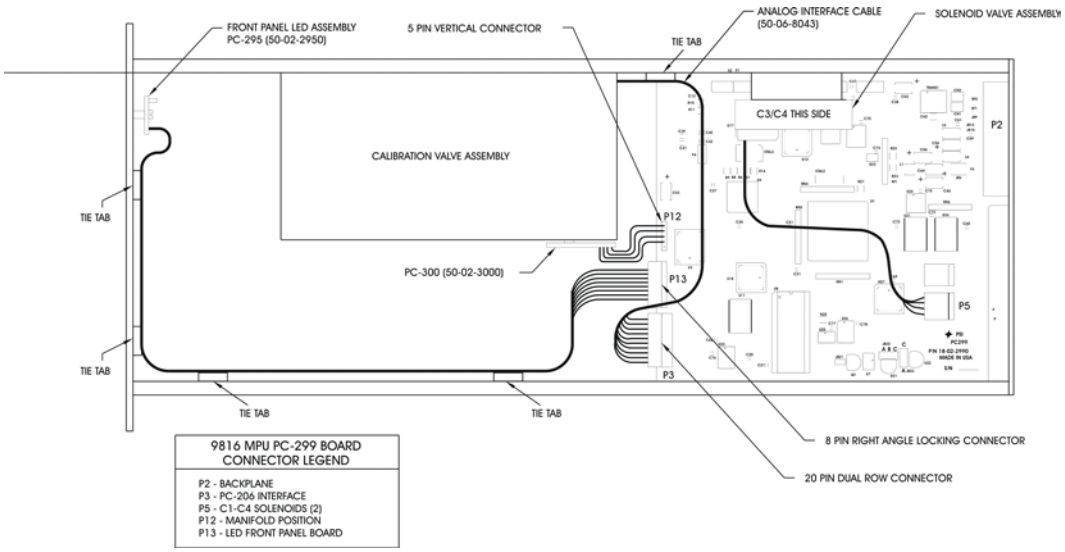


Figure 5.6
PC-299 Board with Cable Connections

(4) Place the new PC-299 board in the top and bottom rack rails so that its P-2 connector aligns with the rear panel cutout. Slide the board forward until it aligns with the top and bottom Allen-head set screws. Install the four (4) Allen-head screws, securing the back panels to the top and bottom rails. Re-attach the wiring harnesses to pins P3, P5, P12, and P13 on the PC-299 board. **Ensure proper Pin 1 orientation when installing the ribbon cables.** (Pin 1 of the ribbon cable has a *red stripe*).

(5) Ensure that all wiring harnesses are firmly connected to the PC-299 board and that the harness from the PC-206 board is fitted through the slot under the transducer/cal-valve housing.

(6) Test your scanner to ensure proper operation.

5.1.3.3 Valve Manifold Position Detector Circuit

All **Model 9816 Intelligent Pressure Scanners** are equipped with the purge/leak-charge calibration manifold. Through software commands to each 9816, this valve may be placed in one of four positions; **RUN**, **CAL**, **PURGE**, or **LEAK**. See **Section 2.2.4** for the pneumatic input requirements for these operating positions.

In earlier versions of the **Model 9816**, the manifold valve position detector was comprised of a small printed circuit board (PC-300) mounted on the underneath side of the calibration (cal) valve assembly. The printed circuit board (PCB) used two (2) reflective infrared sensors to sense the actual position of the manifold valve block was connected to P12 of the PC-299 board.

Should replacement of the PC-300 be required, the scanner must be returned to the factory where a new manifold assembly will be fitted. To replace the manifold position detector circuit:

(1) Use the tools and follow the general warnings already described in **Section 5.1.1**

(2) Place the scanner calibration valve in the PURGE position. Disassemble the module as described in **Section 5.1.2**. When the scanner is removed from the chassis, turn it over so that the calibration valve assembly tubing plate is facing up. The micro-switches should both be closed (actuated by the dowel pins attached to the slide valve).

(3) Unplug the manifold position detector four-pin connector from P-12 on the PC-299 board. Take note of the connector orientation. *Remember that all PCBs are sensitive to static discharge.*

(4) Remove the four (4) mounting screws (two from each switch) that attach the micro-switches to the manifold assembly, noting the location of each switch.

(5) Attach the new micro-switches, ensuring that the actuator arm engages the actuator dowel pin. Adjust the dowel pin gently if it does not fully engage the switch.

(6) Return the scanner to its upright position, reassemble the scanner, replace the side panel(s), reinstall the scanner into the rack, and test your scanner to ensure proper operation.

5.1.3.4 Scanner Front Panel LED Assembly

The PC-295 LED board (containing all of the scanner indicator lights) is attached to the front panel of the 9816 scanner with two 4-40 x ½ Phillips-head screws. The PCB is attached either horizontally or vertically, depending on the pneumatic input option of the 9816. Front-mounted tubing using compression fittings requires that the LEDs are mounted vertically, while 9816s using bulge tube QDC inputs have their LEDs installed horizontally.

See drawings **(Figures 5.7a, 5.7b, and 5.7c**):

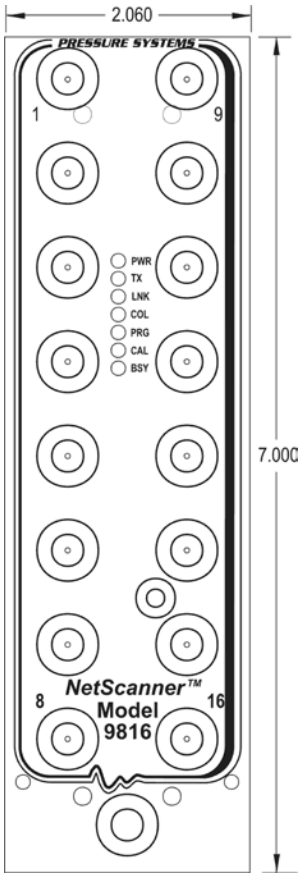


Figure 5.7a
9816 Scanner with Compression Fittings

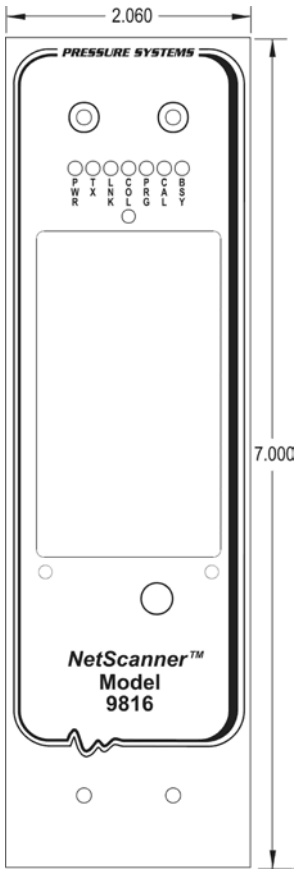


Figure 5.7b
9816 with Front QDC

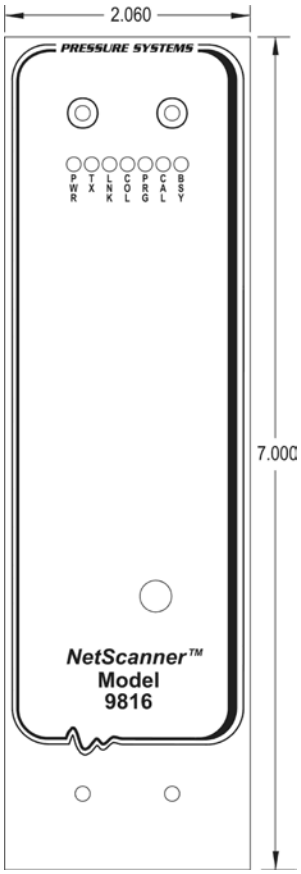


Figure 5.7c
9816 with Rear QDC

Should it be determined that LED maintenance or replacement of the PC-295 board is necessary:

(1) Use the tools and follow the general warnings already described in **Section 5.1.1**, and remove the module side cover(s) as described in **Section 5.1.2**.

(2) Unplug the PC-295 board connector cable from P-13 on the PC-299 board.

(3) Place the 9816 on a flat surface and lay it on its right side. Remove the two (2) Phillips-head screws that hold the front panel to the top rail and the two (2) Allen-head screws that hold the front panel to the bottom rail. (Note, the bottom Allen-head screws also attach the push-pull handle to the front panel.)

(4) Slide the front panel forward as far as it will go (approximately 3/8".)

(5) Remove the two (2) 4-40 x 1/2" Phillips-head screws and remove the PC-295 board and its associated LED indicators. For QDC-tubed scanners, the large network resister on the PC-295 board will be on the 'up' side of the board. If your scanner is front-tubed, with compression fittings, the network resistor will be on the left side of the board. Also, front-tubed scanners with compression fittings use longer LED connectors as well as standoffs. A simple way to remember which way the board mounts is that the **PWR** LED is green and the **BSY** LED is red.

(6) Perform whatever maintenance or replacement is required. If the entire PC-295 board is to be replaced, cut the plastic ties that holds the ribbon cable to the front panel and the bottom rail. Reinstall the two (2) Phillips-head mounting screws (together with the standoffs, if required), and re-assemble the front panel.

(7) Reconnect the PC-295 board cable to P13 on the PC-299 board, install new plastic ties (that hold the PC-295 ribbon cable to the front panel and the bottom rail), replace the side cover(s), replace the scanner into the **98RK-1 Scanner Interface Rack**, tighten the locking rod, and test your scanner to ensure proper operation.

5.1.4 Replacement of Transducers

Model 9816 has *internal* DH200 pneumatic transducers, as well as an *internal* calibration manifold with associated valves and O-rings. Some these elements occasionally require service or replacement as described in the following sections.

Following is a step-by-step procedure to replace a DH200 transducer in a **Model 9816 Intelligent Pressure Scanner**. Use the tools and follow the general warnings already described in **Section 5.1.1.**

(1) Disassemble the module as described in **Section 5.1.2.** Remove the transducer/cal-valve housing from the top chassis rail.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in **Section 5.1.3.1**. Lay the circuit board aside on an anti-static surface.

(3) Remove the retaining screw from the desired DH200 transducer. Lift the transducer straight up to remove it. Make sure that the two (2) O-rings remain with the transducer as it is removed from the adapter plate. Ensure that the adapter plate O-ring sealing surface is clean and free of contaminants. See **Figure 5.8.**

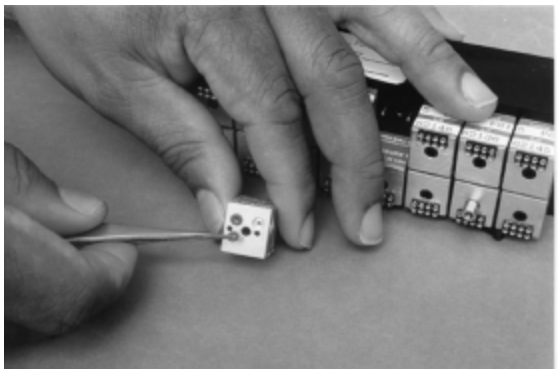


Figure 5.8
Top View of DH200

(4) Replace the DH200, making sure that the electrical connections are located on the outer edge of the cubic design. Be sure that the two (2) O-rings are in place on the DH200 and that O-ring surfaces are free of contaminants. The O-rings should be lightly greased with Krytox® fluorinated grease. The DH200 must fit the guiding pins smoothly and be aligned with all other DH200 transducers. Tighten the retaining screw to 40 inch-ounces ±5 inch-ounces of torque.

Note **The hex-head standoff screws used on DH200 positions 2 and 15 are used to secure the PC-206. These hex-head screws should not be over tightened or else the screw may break.**

(5) Replace the PC-206 board as described in **Section 5.1.3.1** and reassemble the module. Ensure that the two hex-head standoff screws are installed on DH200 positions 2 and 15 and that they align with the two PC-206 mounting holes.

(6) Test your scanner to ensure proper operation.

5.1.5 Model 9816 Solenoid Replacement

The following is a step-by-step procedure to replace the solenoids in a **Model 9816 Intelligent Pressure Scanner**. Modules contain two solenoid valves. Use the tools and follow the general warnings already described at the start of **Section 5.1.1.** Refer to **Section 5.1.6.5** for details concerning solenoid O-ring replacement.

(1) Disassemble the module as described in **Section 5.1.2.**

(2) Remove the two (2) Allen-head screws that secure the solenoid manifold to the module top guide rail. Carefully move the solenoid manifold assembly to one side for easier access. Be careful ***not*** to crimp the attached nylon tubing.

(3) Carefully remove the two (2) Phillips-head screws from the top of the solenoid. Disconnect the solenoid from connector P5 of the PC-299 microprocessor board. See **Figure 5.9 and Figure 5.9a.**

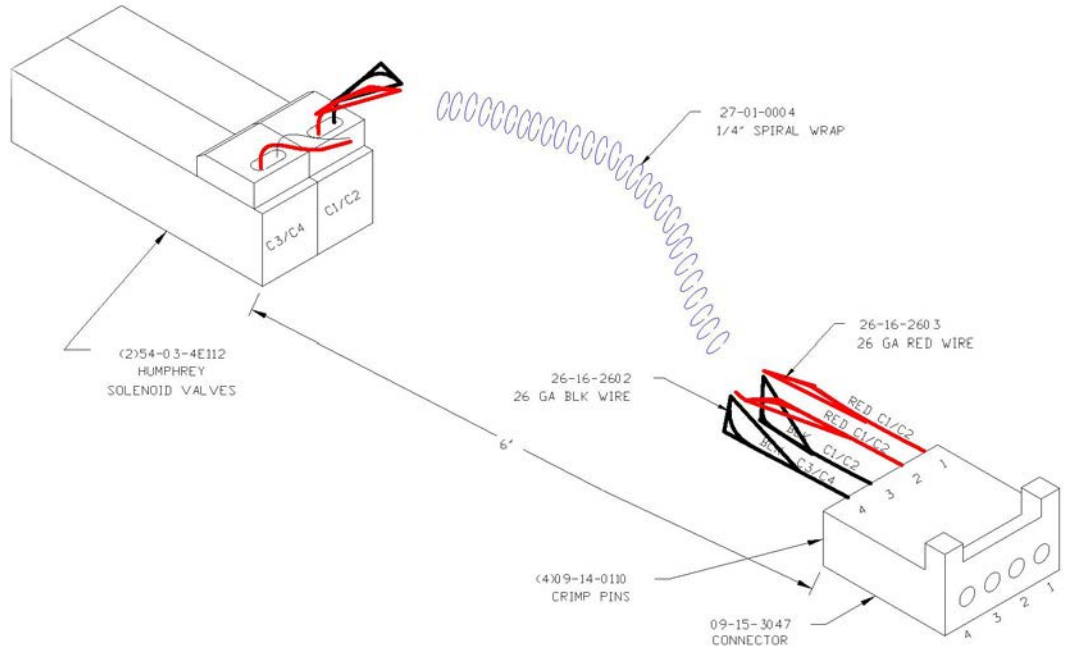


Figure 5.9
Schematic of 9816 Solenoids

(4) If the either the new or old solenoid does not have a pluggable wiring harness at the solenoid, the new solenoid wires will require crimp pins to be installed for insertion in the P5 mating housing. The proper crimp pin is Molex part number 08-56-0110. After installing the crimp pins to the solenoid wiring, remove the old crimp pins from the Molex P5 housing and insert the new solenoid's wiring. Ensure that the new wires are installed in the same position as the old wires.

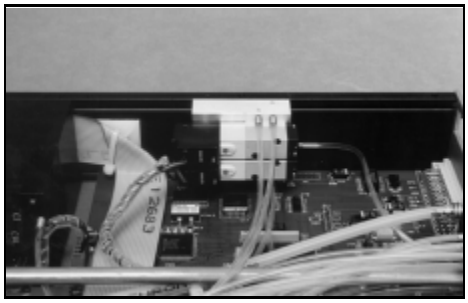


Figure 5.9a
Solenoids Attached to Module

(5) Ensure that the three (3) solenoid manifold O-rings are present and free of contaminants. Replace the solenoid with the new one by carefully aligning and gently tightening the screws.

(6) Attach the wiring harness to the solenoid and connector P5 of the PC-299 board.

(7) Reassemble the module.

(8) Test your scanner to ensure proper operation.

5.1.6 Replacement of O-Rings

Scanner calibration valves include both static and dynamic O-ring seals. When used properly, the rated durability of the dynamic O-rings is in excess of 1,000,000 shifts of the calibration valve.

The procedures described below should be used for replacement of all the O-rings in the **Model 9816 Intelligent Pressure Scanner**. Use the tools and follow the general warnings already described at the start of **Section 5.1.1**.

The material needed for the O-ring replacement can be acquired through the proper maintenance kit available from MEAS. Specifically needed for these procedures are proper size O-rings, PTFE cup seals, a fast evaporating cleaning fluid (e.g., acetone, alcohol, Freon, etc.), 50 PSI dry air supply, a glue syringe and glue (for those O-rings needing glue),and Krytox® fluorinated grease **(read product warnings and recommendations thoroughly)**. **Service of O-ring seals requires a clean working environment.** Introduction of contaminants to the O-ring or internal calibration manifold surfaces can result in internal pneumatic leaks. *Inspection for contaminates generally requires some type of magnification device, such as a microscope*.

5.1.6.1 DH200 Pressure Transducer O-Ring Replacement

Please note that the DH200 O-rings are used for static seals only. They will typically not require replacement unless exposed to improper liquid media (which will also damage other 9116 components). Following is a step-by-step procedure to replace a DH200 O-Ring should it be required:

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in **Section 5.1.3.1.** Lay the circuit board aside on an anti-static surface.

(3) Remove the DH200 transducer(s) as described in **Section 5.1.4.** If more than one DH200 is removed, it is recommended to record their serial numbers prior to removal to ensure they are reinstalled in the same locations.

(4) Using tweezers, remove the two (2) O-rings from the DH200. Clean the O-ring cup with a lint-free applicator moistened with a cleaning fluid such as acetone, alcohol, Freon, or any other substance that evaporates quickly and leaves very little residue. Remove any excess cleaner with the air supply as soon as possible. Do not blow air directly into the holes of the surface since that can drive the fluid into the transducer and/or rupture the silicon pressure transducer.

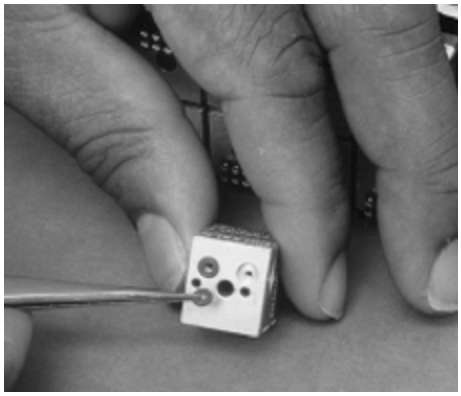


Figure 5.10:
DH200 Transducer O-Ring Replacement

(5) With clean hands, apply a small amount of Krytox® fluorinated grease to the palm of one hand and rub it out evenly with your index finger. Place one new O-ring onto your greased palm. Work the O-ring around until it is evenly greased. The O-ring should shine when properly lubricated. There should be no white area of excess grease on the O-ring. Make sure there is only a thin film of lubrication on the O-ring. Using your greased finger, place the greased O-rings in the cups on the DH200. Ensure that no grease enters the hole that leads into the transducer.

(6) Reinstall the DH200 as described in **Section 5.1.4**

(7) Repeat steps 3, 4, 5 and 6 for each set of O-rings in need of replacement.

(8) Replace the PC-206 board as described in **Section 5.1.3.1** and reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.2 Tubing Plate O-Ring Replacement

The following is a step-by-step procedure to replace a Tubing Plate O-ring in a **Model 9816 Intelligent Pressure Scanner**.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Place the scanner with the tubing plate on a clean, lint free surface.

(3) Hold the top plate/calibration valve assembly with one hand, supporting the bottom assembly to prevent dropping when all screws are removed. Remove the six (6) Allen-head screws on the top plate that secure the valve assembly to the top plate.

(4) Carefully rotate or slide the tubing plate back and forth, pivoting on the guiding pin about 1/8" several times. This is done to loosen the O-rings from the calibration manifold. Lift the tubing plate straight up. Do not touch the calibration manifold.

(5) Remove and replace the O-rings needing maintenance, using the procedure described in **Section 5.1.6.1.** Note that the O-ring seals use an additional PTFE cup seal (part number 24-00-50-153) placed on top of the O-ring. These seals should be replaced as necessary. Note that these PTFE seals *do not* require the use of Krytox® grease. Notice also the larger O-rings (part number 61-14-50176 [C3/C4] and 61-14-70101 [Purge]). Replace them in the same manner as described in **Section 5.1.6.1**.

(6) Examine the tubing plate and calibration manifold to verify that no contaminants are on either surface. This generally requires microscopic examination. Replace the tubing plate by slowly placing the plate on the calibration manifold housing. Make sure that the O-ring side is down toward the pneumatic sliding manifold and the guiding pin on the calibration valve housing fits into the mating hole of the tubing plate.

(7) Replace the six (6) Allen-head screws that pass through the top plate to secure the calibration valve assembly. Tighten evenly, making sure that the screws are only finger tight plus 1/8 turn. It is important not to over tighten the screws since the pneumatic seal is made using dynamic O-rings.

(8) Reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.3 Adapter Plate O-Ring Replacement

Following is a step-by-step procedure to replace an adapter plate O-ring in a **Model 9816 Intelligent Pressure Scanner**. The adapter plate is located opposite the tubing plate on the calibration manifold. All DH200 transducers are attached to the adapter plate.

(1) Disassemble the module as described in **Section 5.1.2**.

(2) Remove the PC-206 Amplifier/Multiplexer board as described in **Section 5.1.3.1.** Lay the circuit board to the side on an anti-static surface.

(3) Remove the six (6) 3/32" Allen-head screws that secure the adapter plate to the calibration valve housing. To remove the two (2) center screws, you must remove the DH200 transducers near the screws. Make sure to note the DH200 serial number and location.

(4) Carefully rotate or slide the adapter plate back and forth, pivoting on the guiding pin about 1/8" several times. This is done to loosen the O-rings from the calibration manifold. Lift the adapter plate straight up. *Do not touch the calibration manifold*.

(5) Remove and replace the O-rings needing maintenance using the procedure described in **Section 5.1.6.1.** Note that the O-ring seals use an additional PTFE cup seal placed on top of the O-ring. These PTFE seals *do not* require Krytox® grease.

(6) Examine the adapter plate and calibration valve surface to verify that no contaminants are on either surface. This generally requires microscopic examination. Replace the adapter plate by slowly placing the plate on the calibration manifold housing. Make sure that the O-ring is down toward the pneumatic sliding manifold and the guiding pin on the adapter plate fits into the mating hole of the calibration valve housing. Fasten the adapter plate evenly on all sides.

(7) Install the DH200 transducers that were previously removed. It is suggested to install them back in their original location.

(8) Replace the PC-206 board as described in **Section 5.1.3.1** and reassemble the module.

(9) Test your scanner to ensure proper operation.

5.1.6.4 Calibration Manifold Piston O-Ring Replacement

Following is a step-by-step procedure to replace calibration manifold piston O-rings in a Model 9816 Intelligent Pressure Scanner. There are eight (8) pistons, each with an O-ring, inside the calibration valve housing; one (1) on each end of the housing and three (3) on each side of the calibration valve itself.

(1) Disassemble the module as described in **Section 5.1.2.**

(2) To minimize the possibility of damage, remove the PC-206 Amplifier/Multiplexer board as described in **Section 5.1.3.1.** Lay the circuit board aside on an anti-static surface.

(3) Remove the tubing plate as described in **Section 5.1.6.2**.

(4) Using your index finger, shift the calibration manifold back and forth several times to loosen its connection with the adapter plate O-rings. Carefully lift the calibration valve housing with one hand and turn it over, allowing the calibration manifold fall into the free hand. It is imperative that the calibration manifold does not fall on a hard surface since scratches on the manifold could result in pneumatic leaks.

(5) To remove the six (6) pistons from their slots on the manifold valve, hold the valve in one hand, and apply air pressure of approximately 30 psi (200 kPa) to the C3/C4 input passages on the valve. The passages (0.043" diameter holes) are located on the side of the valve next to the *tubing plate*, one hole on each side of the valve. Pressure on one side will release three (3) pistons, and pressure on the other side will release the other three (3). Thoroughly clean the pistons with a fast evaporating cleaning fluid that leaves little or no residue (e.g., acetone, alcohol, Freon, etc.) and dry with supply air. Replace the piston O-rings (part number 61-03-58610) after lightly lubricating the rings with Krytox® fluorinated grease. Replace the pistons in their cavity by placing the O-ring side of the piston in first and then pressing the piston completely into its cavity with one finger.

(6) To remove the two (2) C1/C2 pistons from their slots on either end of the manifold valve housing, hold the manifold valve housing in one hand, and apply approximately 30 psi (200 kPa) to the two bulge tubes, one on either end of the housing end-plate. This will result in the pistons being forced out of their cavity. If the pistons stick, apply a higher pressure. Place your free hand over the calibration valve housing to prevent the pistons from coming out of the housing. Clean the pistons, lubricate and replace the O-rings (part number 61-12-2023), and replace the pistons into their cavities as described in (5) above.

(7) Thoroughly clean the calibration manifold with a fast evaporating cleaning fluid that leaves little or no residue (e.g., acetone, alcohol, or Freon). Replace the calibration manifold into the housing, making sure that the guiding pin fits into the slot of the manifold housing.

(8) Replace the tubing plate as described in **Section 5.1.6.2.**

(9) Replace the PC-206 board as described in **Section 5.1.3.1** and reassemble the module.

(10) Test your scanner to ensure proper operation.

5.1.6.5 Solenoid Valve O-Ring Replacement

The following is a step-by-step procedure to replace the internal solenoid valve O-rings in a Model 9816 Intelligent Pressure Scanner. The modules contain two internal solenoid valves.

(1) Disassemble the module as described in **Section 5.1.2.**

(2) Remove the two (2) Allen-head screws that secure the solenoid manifold to the module top guide rail. Carefully move the solenoid manifold assembly to one side for easier access. Be careful ***not*** to crimp the attached nylon tubing.

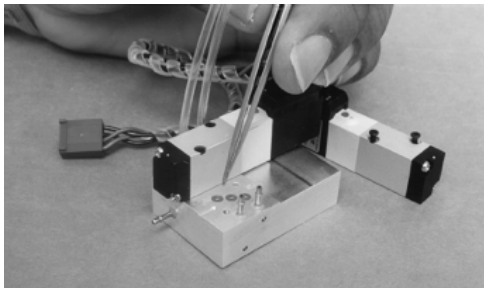


Figure 5.11
Solenoid Valve O-Ring Replacement

(3) Remove the solenoid valve by unscrewing the two Phillips-head screws on top of the solenoid, and following the procedures described in **Section 5.1.5**. Gently lift it out of the module.

(4) Remove and replace the O-rings (red) (part number 61-02-3063) needing maintenance using the procedure described in **Section 5.1.6.1.**

(5) Replace the solenoid valve and gently tighten the screws.

(6) Reassemble the module.

(7) Test your scanner to ensure proper operation.

5.1.6.6 Module Rear Manifold O-Ring Replacement

If a leak is suspected at the module rear manifold:

(1) Remove the module from the **98RK-1 Scanner Interface Rack** by unscrewing the locking rod (turn counterclockwise with a 5/64" Allen-head screwdriver) and slide the entire module chassis out of the rack (as previously described in **Section 5.1.2**).

(2) Inspect the rear manifold O-rings and if any are suspect, carefully remove with tweezers. (Do not scratch the manifold block, as this may induce additional leaks.)

(3) Clean the O-ring cup with a lint-free applicator moistened with a cleaning fluid such as acetone, alcohol, Freon, or any other substance that evaporates quickly and leaves very little residue. Remove any excess cleaner with supply air (dry) as soon as possible. Do not blow air directly into the holes of the surface since that could drive the fluid into the scanner.

For glued O-ring replacement

(4a) There are only two O-rings on this panel that are glued, the larger black ones. One is for the ***purge*** port and the other surrounds a blanking pin. Using a glue syringe, line the O-ring cup(s) with appropriate glue, such as *3M Scotch Grip 1357*. Insert a new O-ring (part number 61-03-50120) and press it into the cup with your hand. Allow the glue to dry for approximately 10-15 minutes. Clean any excess glue with appropriate cleaning solvent, and dry. Be extremely careful not to allow *any* excess glue to cover the tubing ports.

For non-glued (flared post) O-ring replacement

(4b) With clean hands, apply a small amount of Krytox® fluorinated grease to the palm of one hand and rub it out evenly with your index finger. Place one of the new (red) O-rings onto your greased palm. Work the O-ring around until it is evenly greased. There should be no white area of excess grease on the O-ring. Make sure there is only a thin film of lubrication on the O-ring. Using your greased finger, roll the greased O-ring over the flared portion of the tubing connector and into the O-ring cup. Ensure that no grease enters the hole that leads into a transducer.

For all

(5) Apply a very small amount of Krytox® fluorinated grease to the entire manifold, being careful *not* to allow any excess grease into any tubing port.

(6) Slide the module back into the **98RK-1 Scanner Interface Rack** and screw the locking rod clockwise (using a 5/64" Allen-head screwdriver) until tight.

(7) Test the scanner to ensure proper operation.

5.1.6.7 Solenoid Valve O-Ring Replacement

The rear panel quick disconnect (QDC) block (if your **98RK-1 Scanner Interface Rack** is equipped for rear-mounted tubing) may be removed as a complete unit (eight QDC blocks attached to a non-removable eight-piece manifold) and may be re-installed as a complete unit or each of the eight blocks may be re-installed individually. Each rear QDC consists of an "H" block, tubed to an adapter plate, and a tubing plate. There are O-rings on the "H" block and the tubing plate. If a leak is suspected in the rear panel quick disconnect (QDC) block.

(1) Remove eight (8) 10-24 x ½" stainless steel (ss) Phillips-head screws. One screw is used to hold each of the eight (8) modules to its individual adapter plate.

(2) Remove four (4) 6-32 x ¼" stainless steel (ss) Phillips-head screws from the sides of the rear panel QDC mounting plate, and three (3) 4-40 x d" anodized Allen-head screws from the bottom of the rear panel QDC mounting plate.

(3) Remove the entire QDC assembly.

(4) Inspect the rear QDC ("H" block and tubing plate) O-rings and if any are suspect, carefully remove with tweezers. (Do not scratch either the "H" block or the tubing plate, as this may induce additional leaks.)

(5) Clean the O-ring cup with a lint-free applicator moistened with a cleaning fluid such as acetone, alcohol, Freon, or any other substance that evaporates quickly and leaves very little residue. Remove any excess cleaner with supply air (dry) as soon as possible. Do not blow air directly into the holes of the surface since that could drive the fluid into the scanner.

(6) Apply a very small amount of Krytox® fluorinated grease to the entire manifold ("H" block and tubing plate), being careful *not* to allow any excess grease to cover any tubing port.

(7) Re-install the QDC assembly. It is extremely critical that each "H" block tubing assembly be mated *exactly* to its adapter plate on the eight-piece manifold. For this procedure, it may be prudent to disassemble each QDC from its mounting rack and individually re-install it. To remove each QDC from its mounting rack, remove the four (4) 4-40 d" Allen-head screws (one in each corner of the QDC).

(8) Mount the "H" block tubing assembly to its adapter plate on the eight-piece manifold and secure with its 10-24 x ½" stainless steel Phillips-head screw. Assemble each of the tubing blocks in this manner, and then re-connect them to the mounting plate with the Allen-head screws.

(9) Re-connect the QDC mounting rack to the 98RK-1 chassis with the four (4) 6-32 x ¼" stainless steel Phillips-head screws (at the ends) and the three (3) 4-40 x d" anodized Allen-head screws.

(10) Test your scanner to ensure proper operation.

5.1.6.8 Front Panel Tubing Plate Quick Disconnect (QDC) O-Ring Replacement

The front panel quick disconnect (QDC) blocks (if your **98RK-1 Scanner Interface Rack** is equipped with front-mounted tubing) are individually removed. If a leak is suspected in the front panel quick disconnect (QDC) block:

(1) Remove the six (6) 4-40 x 3/8" anodized Allen-head screws from the face plate of the front QDC, and remove the QDC panel.

(2) Inspect the front QDC O-rings and if any are suspect, carefully remove with tweezers. (Do not scratch the QDC block, as this may induce additional leaks.)

(3) Clean the O-ring cup with a lint-free applicator moistened with a cleaning fluid such as acetone, alcohol, Freon, or any other substance that evaporates quickly and leaves very little residue. Remove any excess cleaner with supply air (dry) as soon as possible. Do not blow air directly into the holes of the surface since that could drive the fluid into the scanner.

(4) With clean hands, apply a small amount of Krytox® fluorinated grease to the palm of one hand and rub it out evenly with your index finger. Place one of the new (red) O-rings onto your greased palm. Work the O-ring around until it is evenly greased. There should be no white area of excess grease on the O-ring. Make sure there is only a thin film of lubrication on the O-ring. Using your greased finger, roll the greased O-ring over the flared portion of the tubing connector and into the O-ring cup. Ensure that no grease enters the hole that leads into a transducer.

(5) Apply a very small amount of Krytox® fluorinated grease to the entire manifold, being careful *not* to allow any excess grease to cover any tubing port.

(6) Re-install the QDC assembly. Use the aligning pin in the QDC panel to ensure that proper pin alignment.

(7) Test your scanner to ensure proper operation.

5.1.6.9 Supply Air and Purge Air Sensing Transducers

The pneumatic input manifold (pneumatic backplane) on the **98RK-1 Scanner Interface Rack** contains two (2) additional DH200 transducers to provide facility measurements for additional diagnostic capabilities. The transducers read supply air pressure and purge air pressure. Proper supply air is required to move the calibration valve to implement such functions as re-zero or purge. Proper purge pressure is required to blow contaminants away from the module. Without a sufficient amount of purge pressure, contaminants could migrate back into the calibration valve assembly and cause catastrophic damage to the scanner. Pressures detected by these transducers may be read through the **NUSS** application or through the TCP/IP connection with an appropriate '**r**' command. The pressures associated with these transducers are read as channels 17 and 18 (of a sixteen (16) channel scanner) and are displayed *before* the scanner channel pressures.

Following are procedures for replacing the supply air and purge air sensing transducers and/or their associated O-rings on **98RK-1** racks.

(1) Make sure the **98RK-1 Scanner Interface Rack** power switch is in the **OFF** position and the unit is unplugged from electrical power. Make sure there is no pressure applied to any of the input ports.

(2) Remove the eight (8) Phillips-head screws (front and side) holding the backplane panel in place. Gently pull the panel out and allow it to rest on the power supply leads and the ribbon cable connecting the rear panel to the back plane.

Note

As you are looking at the pneumatic backplane, the two transducers are on the right side of the pneumatic input manifold; the purge-sensing transducer is on the right and the supply-sensing transducer is on the left.

(3) Remove the two grommets that cover the access holes in the *top* of the **98RK-1** chassis (directly over each transducer). Note: it may be easier, with less opportunity to abrade the chassis, to punch the grommets out from underneath, using your Allen-head or Phillips-head screwdriver.

(4) Remove the 3/32" Allen-head screw from each of the transducers, being careful not to drop the screw behind the manifold assembly. These screws attach to stand-offs and act as stabilizers for the flex circuit.

(5) Unplug the eight-pin flex circuit from both DH200s (transducers). The flex circuit is a single-piece unit that must be unplugged from both transducers.

(6) Remove the transducer by removing the 4-40 threaded stand-off screw and lifting the transducer straight up from the mounting block. Make sure the two (2) O-rings remain with the transducer as it is removed and the mounting block is clean and free of contaminants. To replace the transducer O-rings, use the procedure as described in **Section 5.1.4**. If the entire transducer is to be replaced, make sure to also replace the O-rings. Additionally, ensure that the replaced transducer is the same pressure rating as the old one.

Note

The pressure rating of the purge-sensing transducer is 750 psi and the pressure rating of the supply-sensing transducer is 150 psi.

(7) Replace the transducer, making sure the electrical connections are located on the outside (back) edge of the cubic design. Tighten the 4-40 standoff screw snugly (finger tight plus ¼ turn).

(8) Reattach the flex circuit, ensuring it is attached to the same pins from which it was removed, and that the pins are not bent. Replace the 3/32" Allen-head stabilizing screw into each of the transducer 4-40 standoffs.

(9) Ensure all back panel electrical connections are in place, and replace the back panel by sliding it into position and re-installing the eight (8) Phillips-head retaining screws.

(10) Test your 98RK-1 Scanner Interface Rack to ensure proper operation.

5.1.7 Front Pull-out Slide Tray

The front pull-out slide tray contains the PC-363 Ethernet controller board and the **98RK-1** power supply. **Neither** of these components is considered to be field-repairable. If it is determined that maintenance is required on either of these units, the entire pull-out tray should be returned to Measurement Specialties for replacement.

Switches for setting *Cluster* and *Rack* (physical) addresses are located on the PC-363 board (Cluster address) and on the front panel (Rack address). See **Chapter 3, "Read Module Status" (Command 'q')** for more information regarding scanner physical addresses.

5.2 Upgrading Module Firmware

All **NetScanner™ System** Intelligent Pressure Scanner modules contain electronically re-programmable memory devices that store the module firmware. Measurement Specialties will provide new releases of module firmware for enhanced instrument performance whenever updates or modifications are made. All scanner modules may have their firmware downloaded via their Ethernet Host Port. This allows for firmware upgrade while the module is installed in its normal communications network environment. Any new firmware releases (and any available utility programs) may be obtained free of charge by contacting the factory for a copy on DOS/Windows compatible diskette(s) or CD-ROM or by downloading from our website at www.meas-spec.com. Download links can be found in the information page for each model (e.g., NetScanner). All firmware is stored as a self-extracting .ZIP file. Once downloaded from the internet, simply execute the download file to extract the archived file(s).

5.2.1 Upgrading Firmware via Host TCP/IP Port

For the **NetScanner™ System** Intelligent Pressure Scanners with Ethernet (TCP/IP) Host Port, new firmware may be upgraded by the host computer, or any computer on the TCP/IP network, directly via the module's Host Port. It is recommended that any new firmware update file be installed to a suitable subdirectory of your hard disk for better performance. Installation instructions for this support software are provided with the application. Ensure that the TCP/IP communications is properly configured for the PC running the application. The following steps describe how to use this program to upgrade module firmware via your TCP/IP network.

- Establish a connection to the module in accordance with the directions given with the **NUSS** application. Once the connection to the module has been established, four (4) menu selections become available, including one labeled **"Update Firmware".** Selecting this option opens an additional window that allows the user to download new firmware to the module. (See screen depiction, next page, **Figure 5.12**.)

- Locate the update file to be downloaded. Once this has been accomplished and entered on the line "*Name of File to Download,*" the "Download" button will become active.

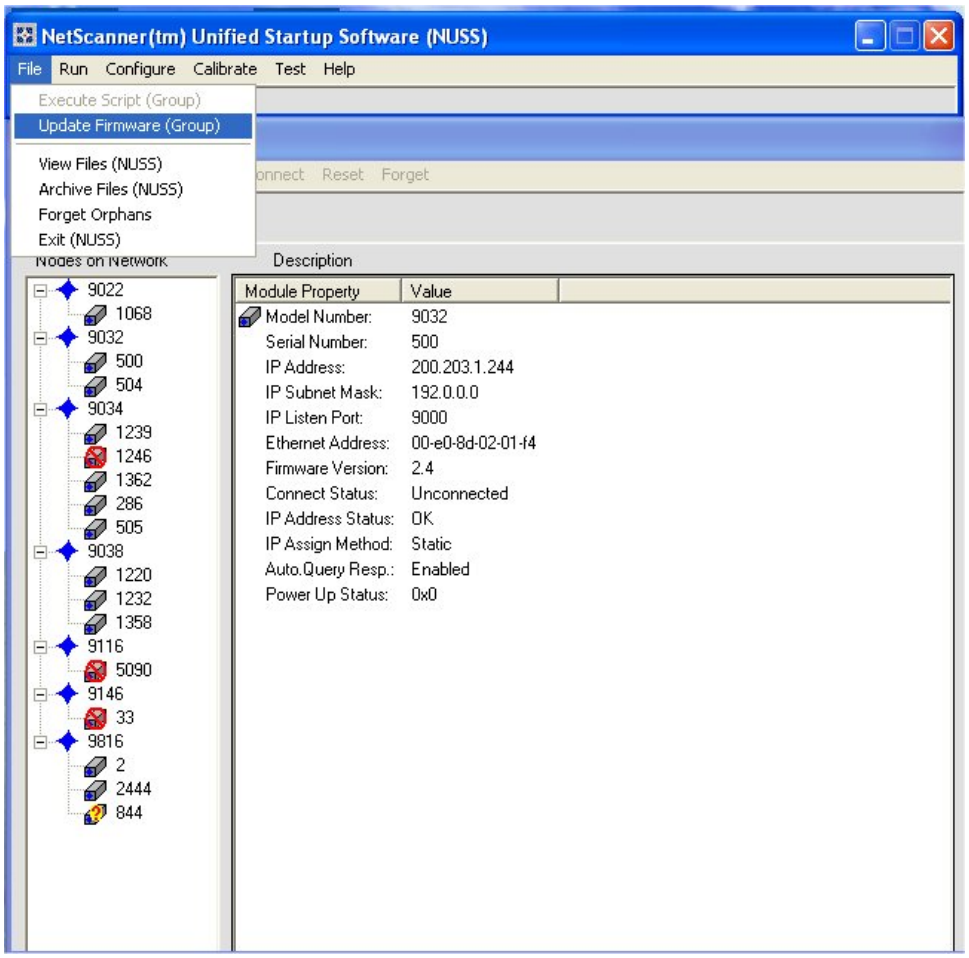


Figure 5.12
Update Firmware Screen

- Click the "Download" button to begin sending the file to the module. A progress bar displays how much of the file has been sent. This "Status" field will display the status of the download.

- The module automatically "re-boots" for acceptance of the new firmware. This entire process requires approximately two (2) minutes.

WARNING: While updating module firmware, DO NOT power-cycle your 98RK-1, the 9816 scanner, or your PC. If the firmware update procedure is interrupted by any of these practices, the module may be left in a "permanent" inoperable state with no operable firmware to reboot it. The ONLY acceptable way to interrupt the firmware update process is to select "Abort Download before the flash memory begins to be overwritten. In the event of such failure, module operation can only be restored by unplugging the 'bad" flash chip and installing a "good" flash chip containing a valid working firmware version."

Chapter 6

Troubleshooting Guide

6.1 98RK-1 Scanner Interface Rack and Module Troubleshooting

6.1.1 Checking 98RK-1 Scanner Interface Rack Power-up Sequence

(1) Power to the 98RK-1 should first be verified. Since all internal and external modules are powered by the 98RK-1 Scanner Interface Rack, make sure the rack is plugged into the proper type of power receptacle.

(2) Turn the rack power switch **ON.** All tray front panel LEDs should illuminate briefly. Verify the 98RK-1 front panel LED status, as described below.

- LEDs labeled " **Power Indicators**" (four (4) LEDs, labeled +12, -12, +5, and +24) should remain **ON**.

  If these LEDs are not on, all other 98RK-1 LEDs as well as the individual module LEDs will likely be off. Make sure the rack is plugged into a proper power receptacle and check that the fuses on the PC-363 board (in the pull-out tray) are
  . intact.

- **Collision** LED should remain **OFF**.

- **Link** LEDs (Local: 1-8; and Remote: 1-3 and Host) should remain **ON** or blinking (for rack slots or remote connectors with attached or installed **NetScanner™ System** products only). The color of the Link LED reflects the negotiated interface speed: yellow for 10T, green for 100T, and blue for 1000T. These LEDs indicate proper Ethernet connections.

6.1.2 Checking Module LED Power-Up Sequence

(1) Power to each module should be verified. Since module power is supplied by the **98RK-1 Scanner Interface Rack**, make sure that the rack is plugged into the proper type of power receptacle.

(2) Turn the rack power supply **ON** and verify the front panel LED status (for each installed scanner) following initial power-up:

- **PWR** LED should remain **ON**.
  If this LED is not on, all other LEDs will likely be off. Make sure the module is properly seated (mated) with the rack and the rack is plugged into a proper power receptacle. Do not unplug or reseat a module while rack power is ON.

- **TX** LED should remain **OFF**.
  Note that any activity of the TX LED during the power-up sequence is an indication that the Dynamic IP assignment protocol is enabled. This will typically occur following the initial **BSY** LED cycle and continue until an appropriate server reply is received.

- **LNK** LED should remain **ON**.
  This LED indicates proper connection to an Ethernet hub or switch. If this LED is off, verify that the rack is properly connected to the communications hub or switch.

- **COL** LED should remain **OFF**.

- **PRG** LED should remain **OFF**.

- **CAL** LED should remain **OFF**.

- **BSY** LED should blink 8-16 times at a rate somewhat slower than 1 Hz, delay **ON** for approximately 30 seconds and then start to continuously blink at approximately 100 Hz (rate is dependent on the number of internal averages). This faster blink rate may simply appear as a dimly-lit LED. Note that the **BSY** LED will not begin its 100 Hz blink rate if the Dynamic IP assignment protocol is enabled and the module has not received a proper IP address response.

Any significant variation from this power-up LED sequence is an indication of a possible rack problem or a 9816 microprocessor board (PC-299) error. If the proper power-up LED sequence is not achieved after following the above suggestions, contact the Repair Department at Measurement Specialties for additional assistance (1-800-678-SCAN).

6.1.3 Checking Module TCP/IP Communications

If the LED indicators of the 9816 scanners and **98RK-1** are correct, the module is normally capable of proper communications. In order for communications to be established with a functional 9816 (assuming correct interface cables are used), two user-controlled parameters must be met. First, the 9816 must be configured to obtain a proper (and unique) module IP address. Second, the user's host computer must have its TCP/IP communications interface properly configured.

6.1.3.1 Module IP Address Assignment

Before an Ethernet 9816 can communicate with a host computer, it must have a valid IP address assignment. As explained in **Section 2.3.3**, there are two methods for assigning an IP address to an Ethernet device, Static and Dynamic. The Static IP is the default method for IP address assignment in the 9816. This is primarily because it allows the module to use its own IP address based on a factory default value. The Dynamic IP addressing is slightly more complicated since it requires a Dynamic IP server to be present and properly configured on the network. Before host communications can be established, the user must ensure that the 9816 has been assigned a known IP address through either using its factory-assigned Static IP or using a Dynamic IP server.

To determine whether Static or Dynamic IP is enabled, observe the module **TX** LED on module power-up. As explained in **Section 6.1.2**, if Dynamic addressing is enabled, the module **TX** LED will flash one or more times during the power-up sequence. If the module receives a valid reply, the **BSY** LED will begin to flash rapidly (appearing dim) and the **TX** LED will remain OFF. If it appears the module received an IP server reply or that it is configured for Static IP addressing, proceed to **Section 6.1.3.2** to verify proper host TCP/IP configuration.

If the module does not receive a response from a Dynamic IP server, its **TX** LED will continue to flash with an increasing delay between **TX** attempts. The **BSY** LED will also remain **OFF** until a server reply is received. If a Dynamic IP reply is not received, verify that a Dynamic IP server is present on the network. If the IP server is present, verify that it contains an entry for the 9816 Ethernet hardware (MAC) address. Verify this address against the Ethernet address printed on the module label to ensure it has been entered correctly into the Dynamic IP server. After making the required changes to the IP server, repeat the above steps until the module receives a valid Dynamic IP reply.

If the user wishes to change the factory set IP Address in a module, manually, it must be done with the **NUSS** program (described more fully in **Section 6.1.3.3**). To use it for this purpose, select the desired module on the **NUSS** *screen map* (left window), then press the right-mouse button to get the module's pop-up *context* menu. From that menu, select the **Change Address Info** option. A new screen then appears that will accept a new IP Address (and other network parameters). After the new address is sent, the module must be "re-booted" (another choice on context menu) before it will take effect.

NOTE: **NetScanner™ modules are factory configured to use a 200.xxx.xxx.xxx IP address with a 192.0.0.0 subnet mask. These addresses were chosen with the understanding that the modules would be run on a totally private network. Addressing errors may occur if modules are connected to a company internal network or if the modules are connected to the Internet. If you are not sure about the configured networking scheme, please consult your network administrator.**

NOTE: **NetScanner™ modules are currently designed to use RARP protocol and BOOTP protocol for Dynamic IP address assignment. When placed in Dynamic addressing mode (through UDP Query's "Enable Dynamic IP" command, or through the TCP/IP protocol 'w1301'command), the modules will first try to resolve their addresses using RARP protocol. If no RARP server can be found, the modules will then use the BOOTP protocol. The modules will alternate between these two protocols until a response is received and an IP address is assigned. If you are not sure about these protocols, or if your modules should be using them, please contact your network administrator.**

NOTE: **When using the *Configure/Control Multi-Point Calibration* ('C') command, only the local variables in the module's volatile main memory (RAM) are changed. Refer to Section 4.5 if it is desired to also store these new *offset* and *gain* coefficients in transducer non-volatile memory.**

6.1.3.2 Host IP Address Assignment for Windows® Operating Systems

In order to communicate with the Ethernet 9816, the host computer must also be configured with an appropriate IP address. For most Windows®,-based operating systems, a typical configuration is described below. Note that this configuration assumes that a host PC Ethernet adapter is installed and not in use for any other TCP/IP application. If your Ethernet adapter is used for other TCP/IP communications, contact your network administrator to determine proper host IP address and subnet mask configurations before proceeding.

Activate the Windows control bar (left click the **STAR**T icon). Select the **SETTINGS** line followed by the **CONTROL PANEL** folder. In the **CONTROL PANEL** folder, select the **NETWORK** icon. Once in the **NETWORK** setup, select the tab labeled **CONFIGURATION**. Scroll through the list of installed configuration protocols. Select the one labeled **'TCP/IP-.xxxx'** where xxxx will typically identify your Ethernet adapter card. There may be other TCP/IP protocols listed for other items such as dial up adapters, these are not used for the **NetScanner™ System** Ethernet configuration. If the TCP/IP protocol is not listed in the configuration menu, left click the **ADD** button. Continue by selecting to add a **PROTOCOL**.

Select **MICROSOFT** from the Manufacturers list. Then select **TCP/IP** from the networks protocol list.

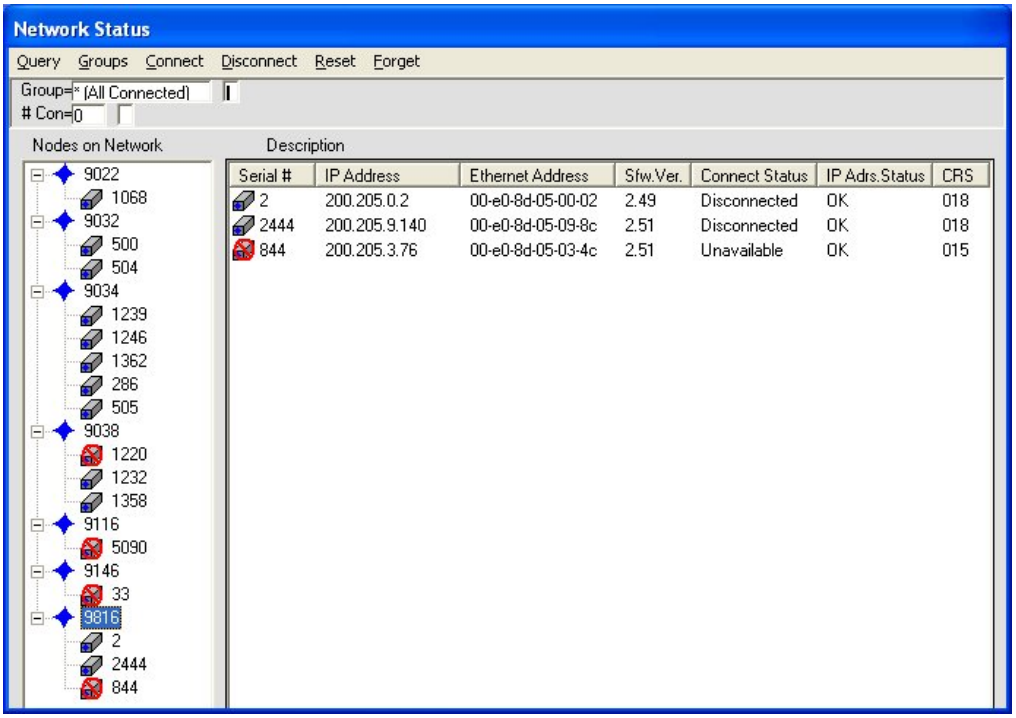
Once in the proper TCP/IP protocol setup, select the **'IP Address'** tab. Click on the button to enable the field **'Specify IP Address.'** Once selected, the fields for IP address and Subnet will be enabled. In the IP address, enter a TCP/IP address for your host computer. An IP address of 200.1.1.1 will work if the 9816 is using the factory default IP address. If the leftmost fields of the 9816 module IP addresses are different than the factory default of 200.xxx.yyy.zzz then the leftmost fields of the host computer's IP address must match the module's leftmost IP address field. In the subnet field, a value of 255.0.0.0 can be entered for most configurations.

When these fields are entered, click the OK icons until Windows prompts you to restart your computer (Windows® 95/98 only). Once the computer has restarted, it should be capable of communications with the Ethernet **NetScanner™ System** module.

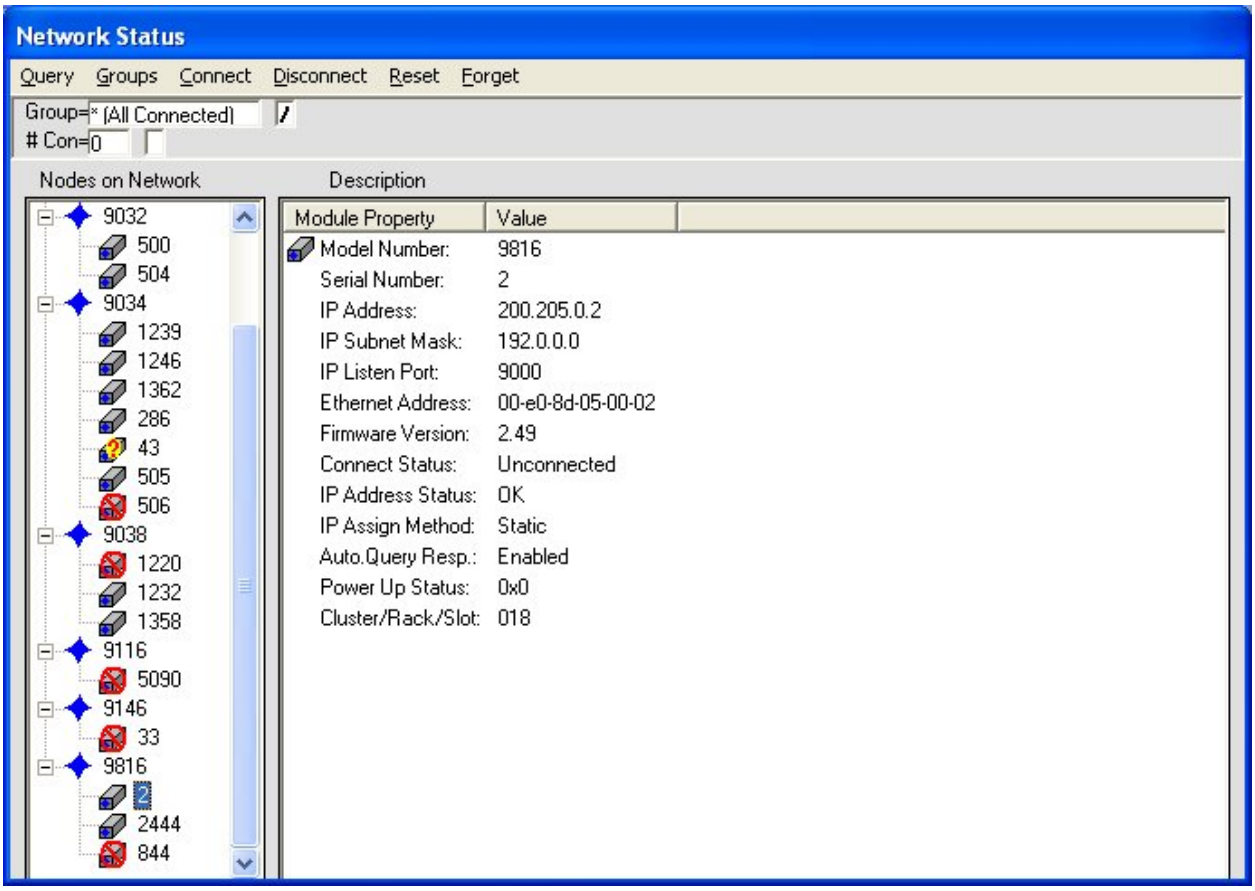
6.1.3.3 Troubleshooting with NUSS (NetScanner Unified Startup Software)

NUSS was developed to show the user how to identify, display, and perform functions of the **NetScanner™ System** family of modules. As such, it is an excellent troubleshooting tool. The **NUSS** application and the User's Manual are on the CD-ROM you received with your **98RK-1**.

The main purpose of **NUSS** is to allow a personal computer (PC) to *query* (talk to) any **NetScanner™ System** module on the network. When the module(s) gets the message(s) from the PC, it returns information about itself to the PC for display and analysis by the user.
For example, the screen depiction below shows all of the various modules on the network. For each of the modules on the network, **NUSS** identifies the module serial number, its IP address, subnet mask, Ethernet address, and power-up status, as well as the other information depicted regarding the particular module.



If you desire to connect with any module on the network, **NUSS** allows you to do that through its UDP/IP protocol commands (see **Chapter 3)**.



All of this can become an invaluable source of information for troubleshooting your modules(s). See **Chapter 5, Section 5.2** regarding updating the module firmware.

6.1.3.4 Verifying Host TCP/IP Communications

At this point, the **NetScanner™ System** module should be configured to obtain its IP address through either Static or Dynamic IP assignment. The module's IP address must be assigned and known in order to proceed. The host computer has also been configured for TCP/IP protocol and assigned an IP address compatible with the **NetScanner™ System** IP address. A simple method to verify proper operation is through the ***ping*** utility. This is a simple TCP/IP utility that is found in Windows® -based operating systems as well as most other TCP/IP packages. The ***ping*** utility simply sends a test packet to the specified IP address and waits for reply to be returned. The **NetScanner™ System** Ethernet modules are programmed to reply to these ***ping*** requests.

To run the ***ping*** utility from Windows®, follow these steps. Left click the Windows **START** button. Move the mouse pointer to **'RUN'** and left click on it. At the prompt, type *'ping xxx.xxx.xxx.xxx'* where xxx.xxx.xxx.xxx represents the IP address of the device to test. The IP address of an Ethernet **NetScanner™ System** module should be used. A small DOS window will appear as the ***ping*** application executes. The ***ping*** program will report either a reply was received or it failed to receive a reply. If the ***ping*** application reported receiving a reply, the host

computer and the **NetScanner™ System** module are both properly configured for TCP/IP communications.

If an error free ***ping*** reply was not received, rerun the ***ping*** application using the IP address of the host computer. This will verify if the TCP/IP protocol was properly configured on the host computer. If a ***ping*** reply was not received, verify the TCP/IP installation steps for your host computer. Also verify that the host computer is configured for the proper IP address and subnet mask.

If the ***ping*** test of the host computer's IP passed while the ***ping*** of the **NetScanner™ System** module failed, check the following possible sources for error:

- Ensure the **NetScanner™ System** module's IP has been assigned (as explained in **Section 6.1.3.1**) and the correct IP was used for the ***ping*** test.
- Ensure the IP address of the host computer and the **NetScanner™ System** module are not duplicated on the network.
- Ensure the link (**LNK**) LEDs are active on both the 9816 and the 98RK-1 for the installed slot. Also ensure the link LEDs are active on the host computer's Ethernet adapter and the optional hub or switch to which it is attached as well as the 98RK-1 Host Link LED.
- Ensure the Ethernet adapter card installed in the host is properly configured without conflict. In Windows®, this can be verified by entering the **CONTROL PANEL** under **SETTINGS**. Under **CONTROL PANEL** select the **SYSTEM** icon. When the **DEVICE MANAGER** tab is selected, a list of all installed hardware devices will be listed. Any possible hardware conflicts will be marked in this list with a yellow warning symbol next to the device in question.
- Ensure the Ethernet adapter is configured for 10 Mbit/Sec. Many adapters are capable of higher speeds that are not compatible with the **NetScanner™ System** modules.

6.2 Zero and Gain Calibration Troubleshooting

Incorrect pneumatic setup or incorrect command usage when executing a module's Re-zero or Span calibration command (see **'Z'**, 'h', and **'C'** commands in **Chapter 3**) can result in unexpected module operation. A common source of errors during these operations is incorrect control of the module's internal calibration valve and pneumatic inputs.

Pressure connections are described in **Chapter 2** while details of calibration procedures are described throughout **Chapter 4**. Some common errors and problems are listed below. These common problems apply primarily to Model 9816, with its internal transducers and calibration manifold.

- The module's supply air is either not attached or does not provide enough pressure (less than 65 psig) to shift the calibration valve. This results in the calibration valve remaining in its current position even though the module commands have requested movement of the valve. This causes incorrect pneumatic inputs during calibration commands. Verify this by reading the

98RK-1 SUPPLY air transducer. Verify the valve position through the '**q0B**' command and front panel LEDs. This command reflects the ***actual*** sensed calibration valve position in the **Model 9816 Intelligent Pressure Scanner**.

- At Re-zero, CAL-REF pressure should be identical to CAL. Typically, both inputs are at atmosphere. However, if you are planning to do a Span Calibration, and the CAL port is connected to a pressure generator, then there is a probability of "trapped pressure" in the CAL line, and atmosphere on the CAL REF port. As a result, the Re-zero procedure will compensate for a *false* offset. If the CAL port is connected to a pressure generator, you must take care to ensure the CAL REF pressure is identical to the CAL pressure at Re-zero time.

- CAL valve position errors are common. Re-zero assumes the Cal valve is in the "RUN" position to begin the event. It then moves the valve to the "CAL" position, does the Re-zero, and returns the valve to the "RUN" position. This default behavior may be defeated by the '**w0B**' command.

  SPAN CAL does not move the CAL valve at all. If you have SPAN CAL pressure applied to the CAL port, you must shift the valve into the "CAL" position using the '**w0C**' and '**w12**' commands. After the calibration, you must shift the valve back to the "RUN" position. Failure to do any of these valve shifts may induce errors into your system.

Chapter 7

Start-up Software

7.1 Introduction

The **NetScanner™ System Unified Startup Software (NUSS)** allows you to operate, from a Windows®-based host PC, a diverse network of pressure or temperature scanner modules and/or standard/calibrator modules of the **NetScanner™ System** type.

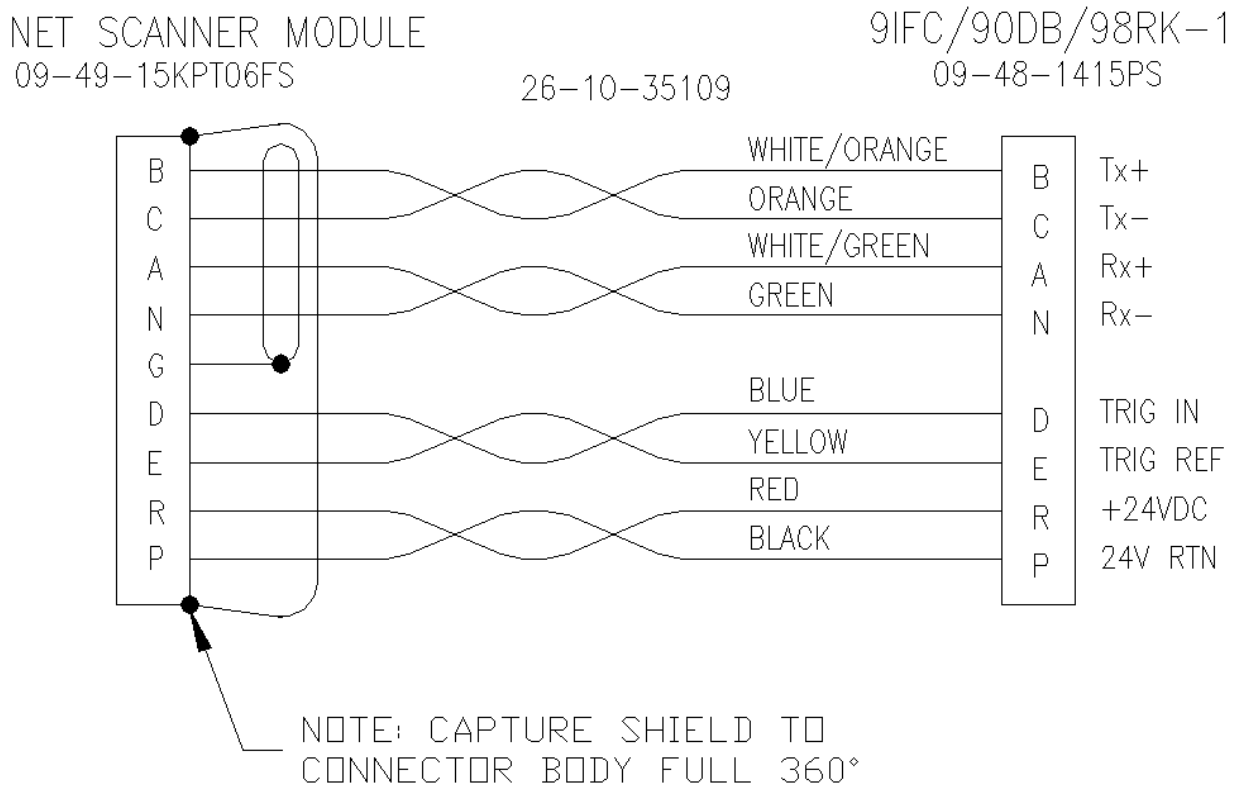
The **NetScanner™ System**, for which **NUSS** was designed, is a distributed Ethernet network (using TCP/UDP/IP protocols) that functions as a precision pressure data acquisition system.

NUSS integrates a diverse set of older "startup," "query," and "test" programs that were often very module-specific. **NUSS** recognizes each **Model 9816** module type it finds on the network and automatically provides that module with its appropriate functionality by dynamically adjusting the program's form and menu content. **NUSS** allows you to operate your **Model 9816** modules singly or together in selected groups without having to write any custom software, and without having to learn low-level commands. The software was designed to permit you to test almost every possible module function with a simple interactive point-and-click interface.

NUSS is provided to all customers who have purchased a **98RK-1 Scanner Interface Rack** with **Model 9816** Intelligent Pressure Scanners installed. The software (**NUSS**) as well as the User's Manual are included on a CD-ROM packed with your shipment. It may also be downloaded from our website, www.meas-spec.com.

Appendix A

Cable Design



NetScanner Ethernet Interface Cable
9082 Cable

Appendix B

NetScanner™ System Range Codes

The following range codes are stored in each DH200 and digital 9400 and 9401 pressure transducer. The range code of each transducer can be read through the Read Internal Coefficient ('u') command, array index 01-10 hex, and coefficient index 0A. *Standard* 9816 Range Codes are **Bold.**

Range Code	Full Scale Pressure	Minimum Calibration Pressure
1	**±.360 psi (±10" Water Column)**	**-0.360 psi**
2	**±.720 psi (±20" Water Column)**	**-0.720 psi**
3	**±1 psid**	**-1.0 psi**
4	**±2.5 psid**	**-2.5 psi**
5	**±5 psid**	**-5 psi**
6	10 psid	-5 psi
7	15 psid	-5 psi
8	30 psid	-5 psi
9	45 psi	0 psi
10	**100 psi**	**0 psi**
11	**250 psi**	**0 psi**
12	**500 psi**	**0 psi**
13	**600 psi**	**0 psi**
14	**300 psi**	**0 psi**
15	**750 psi**	**0 psi**
16	**10 psid**	**-10 psi**
17	**15 psid**	**-12 psi**
18	**30 psid**	**-12 psi**
19	**45 psid**	**-12 psi**

20	20 psid	-12 psi
21	20 psi	0 psi
22	15 psi	0 psi
23	15 psid	-10 psi
24	5 psi	0 psi
25	10 psi	0 psi
26	30 psi	0 psi
27	50 psi	0 psi
28	100 psi	0 psi
29	100 psia	2.5 psi
30	250 psia	25 psi
31	50 psia	2.5 psi
32	500 psia	25 psi
33	750 psia	25 psi
34	30 psia	2.5 psi
35	15 psia	2.5 psi
36	125 psi	0 psi
37	35 psid	-12 psi
38	150 psi	0 psi
39	200 psi	0 psi
40	22 psid	-12 psi
41	60 psid	-12 psi
42	375 psi	0 psi
43	150 psi	0 psi
44	75 psi	0 psi
45	150 psi	0 psi
46	650 psi	0 psi
47	850 psi	0 psi

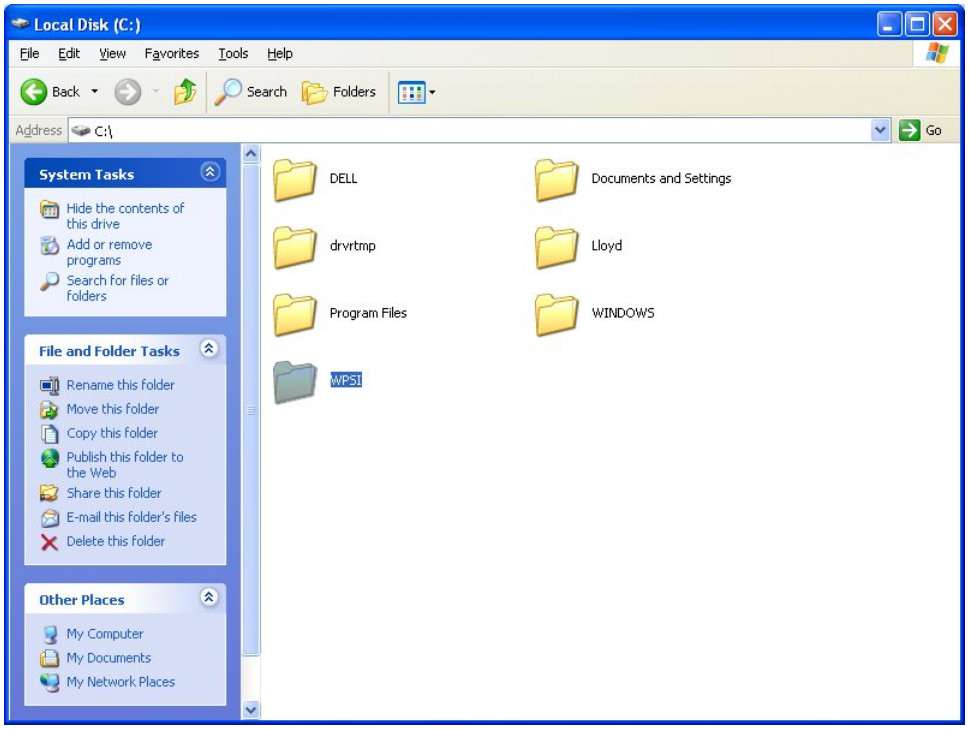
Appendix C

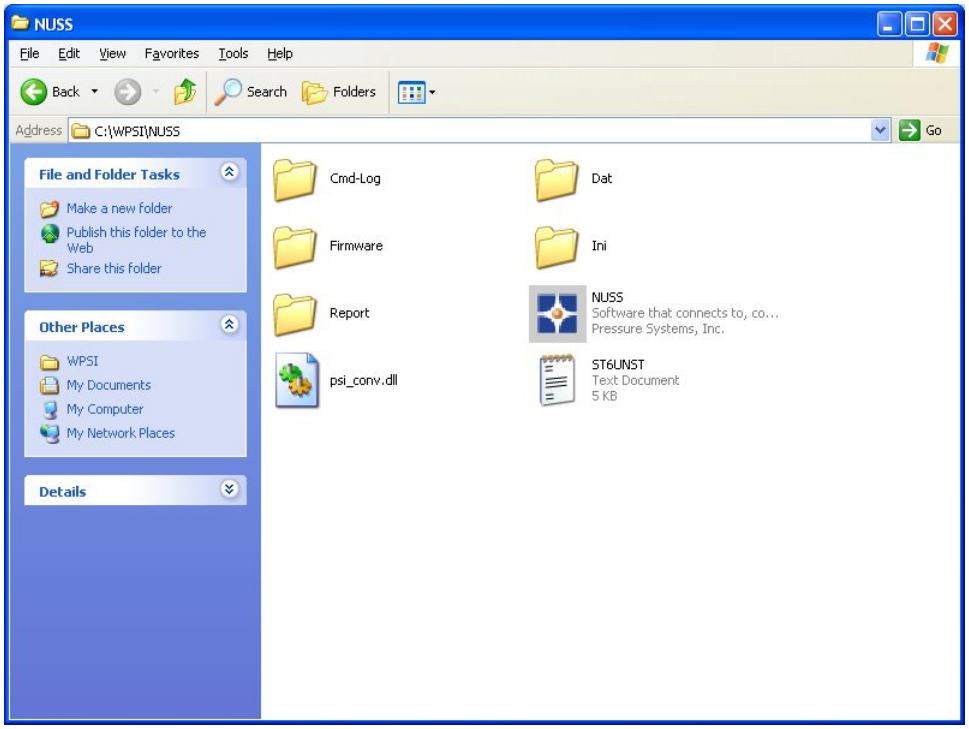
Creating a Shortcut Icon

The following instructions will allow you to create a NETSTART shortcut icon for your PC desktop.

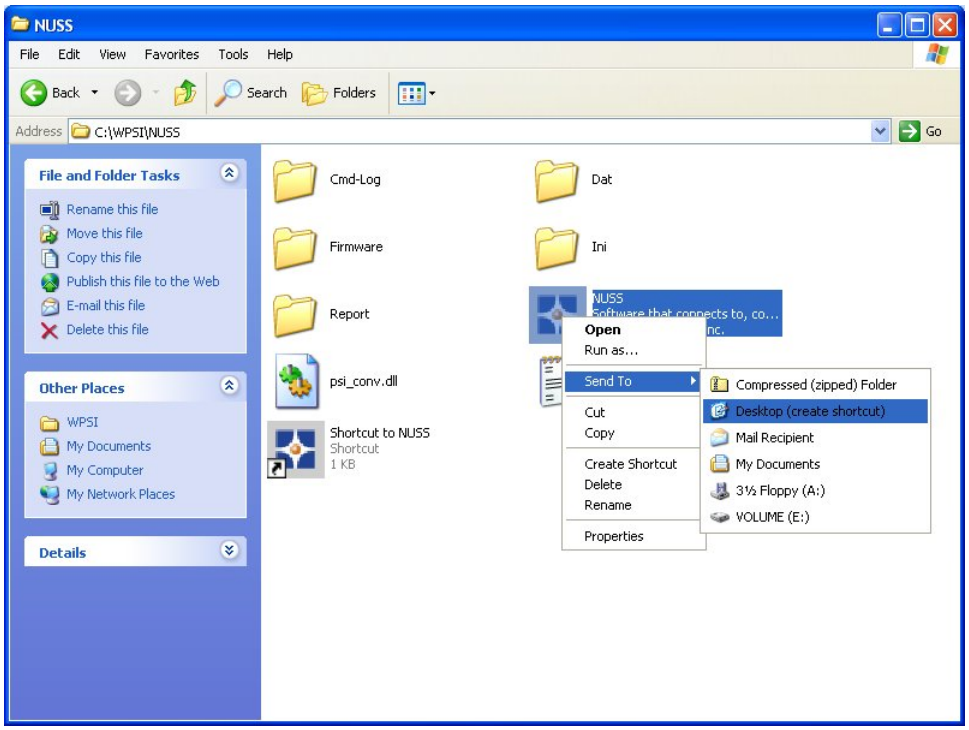
There are two easy methods:

First - to create a shortcut icon (for use on your Windows® XP desktop), use "**My Computer**" and locate the file folder in which your **NUSS** application resides. In the screen example below, it is known that the NUSS file resides in the "WPSI" folder. Double-click (with the mouse) on the **"WPSI"** file folder and the entire **NUSS** file will appear, similar to the screen depiction on the next page.





Select the executable file, in this case the **"NUSS"** file, with one left-click of the mouse, and a drop-down menu will appear.



Slide your mouse pointer down the drop-down menu to the "Send To" line. This automatically opens another menu. Slide down the new drop-down menu and left-click on the "Desktop (create shortcut)" line. This command sends the **NUSS** icon to your desktop.

When you double-click (left mouse button) the **NUSS** icon on your desktop, the **NUSS** applications opens to its initial screen.

Appendix D

Merchandise Return Procedure

If your system seems to be in good working order, but the data seem abnormal, contact the **Application Support Group** or the **Customer Service Department** at Measurement Specialties, Inc. The staff is available for troubleshooting at **(757) 766-1500** or toll-free at **1-800-745-8008** during normal working hours, Eastern Time. If the entire system or any part must be returned to Measurement Specialties Inc., please obtain a *Returned Merchandise Authorization* (RMA) from Customer Service.

Be prepared to supply the following information when requesting the RMA:

- Part number
- Serial number
- Complete description of problems/symptoms
- **Bill To** and **Ship To** address
- Purchase order number (not required by warranty repairs)
- Customer contact and telephone number

The above information, including the RMA number must be on the customer's shipping documents that accompany the equipment to be repaired. MEAS also requests that the outside of the shipping container be labeled with the RMA number to assist in tracking the repairs. All equipment should be sent to the following address:

ATTN: REPAIR DEPARTMENT (7-digit RMA number)
Measurement Specialties Inc.
1000 Lucas Way
Hampton, Virginia 23666

MEAS will return warranty items prepaid via UPS GROUND. If the customer desires another method of return shipment, MEAS will prepay and add the shipping charges to the repair bill.

Incoming freight charges are the customer's responsibility. The customer is also responsible for paying shipping charges to and from MEAS for any equipment not under warranty.

All products covered under the MEAS warranty policy will be repaired at no charge. An analysis fee will be charged to quote the cost of repairing any item not under warranty. If, for any reason, the customer decides not to have the item repaired, the analysis fee will still be charged. If the quote is approved by the customer, the analysis fee will be waived. The quote for repair will be based on the MEAS flat rate for repair, calibration, and board replacement. When these prices do not apply, the quote will be based on an hourly labor rate plus parts. All replaced parts are warranted for 90 days from the date of shipment. The 90-day warranty is strictly limited to parts replaced during the repair.